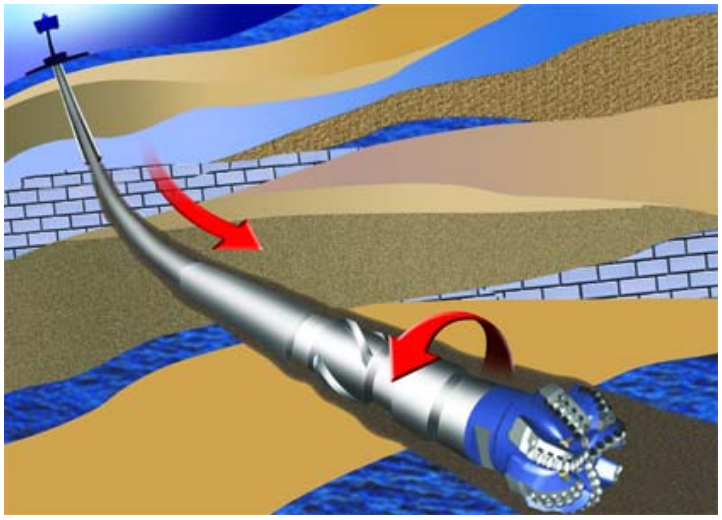
TADPRO

Torque and drag model
Version 4

User's Manual



Pegasus Vertex, Inc.
6100 Corporate Dr., Suite 448
Houston, TX 77036
Tel: 713-981-5558, Fax: 713-981-5556
E-mail: sales@pvicom.com
Web: www.pvicom.com

Table of Contents

I. Introduction

I-1. Background

Torque and drag problems are very common during drilling, completion, and workover operations. Excessive torque and drag in the borehole will result buckling, failure of pipe or operations.

Pegasus Vertex has developed ***TADPRO*** to aid in the calculation of torque and drag along drill strings or casings for various operations.

I-2. Theory and Glossary

(1) Torque and drag

Torque & drag management for on a drill / casing / liner string is one of the key issues related to drilling and tripping operations.

Incorporated into TADPRO is a soft string torque and drag model, which calculates torque and drag (hook load, surface torque) for the following operations:

(a) Drilling
(b) Back reaming
(c) Slide drilling
(d) Rotation on bottom
(e) Rotation off bottom
(f) Tripping in
(g) Tripping out

For the analysis of the buckling phenomena, TADPRO calculates the onset of following buckling status:

(a) Sinusoidal buckling
(b) Helical buckling

Output Window has 3 types of load plots:

(a) History graphs: hook load or surface torque at various string depths.
(b) Snap shots: loads (axial drag, torque, lateral force) vs. measured depth along the pipe at a specified string depth.
(c) Sensitivity analysis: history graphs for various friction factors.

(2) Casing floatation

In Extended Reach Drilling (ERD) wells, the weight of the casing string may not be sufficient to push the string to the well TD. Casing floatation is one of the solutions to this problem.

Floating the bottom portion of the casing reduces the drag against the wellbore, while filling the upper portion with drilling fluid adds weight to the casing string to push it into the hole. This feature facilitates running casing in highly deviated wells and, in many cases, permits successful casing runs that would otherwise be extremely difficult if not impossible.

The key to this technique lies in selecting the correct proportions of air- and mud-filled sections and predicting the hook load during the tripping operations. TADPRO can be used to design and optimize these parameters.

I-3. Engineering Features

- ✓ 3D wellbore / 3D well path visualization
- ✓ Latest casing bending models
- ✓ 20 sections of pipes and 20 wellbore intervals
- ✓ Torque and drag (Hook load, surface torque) calculations for:
  - a) Slack off / pick up
  - b) with or without rotation
  - c) Drilling, rotation off bottom
- ✓ Buckling criteria including:
  - a) Sinusoidal, b) helical
- ✓ Multiple friction factors for different wellbore intervals
- ✓ Casing flotation / Optimal air section length
- ✓ Tripping animation with force / torque profiles
- ✓ Extensive tubular database included
- ✓ Lateral forces
- ✓ Automatically export results into MS Word.
- ✓ Allows oil field, SI and customized units

I-4. Copyright and Disclaimer

TADPRO software and user's manual are copyrighted (2007) by Pegasus Vertex, Incorporated. All efforts were made to assure proper operation and calculation of the ***TADPRO*** program. However, due to the inherent complexity of the analysis, Pegasus Vertex, Incorporated makes no warranties or representations, either expressed or implied, about the suitability of the software including the validity, merchantability or fitness for a particular purpose of any results obtained from the ***TADPRO*** program. Pegasus Vertex, Incorporated shall not be liable for any damages suffered by licensee as a result of using, modifying or distributing this software or its derivatives.

I-5. Technical Support

For any questions, comments or suggestions on ***TADPRO,*** please contact:

Pegasus Vertex, Inc.
6100 Corporate Dr., Suite 448
Houston, TX 77036
Tel: 713-981-5558
Fax: 713-981-5556

E-mail: sales@pvicom.com
Web: www.pvicom.com

II. Getting Started

II-1. Hardware and System Requirements

In general, any IBM-compatible computers using a Pentium processor with Microsoft Windows 98, Windows NT, 2000 and XP will be capable of running the software. Additional resources, such as additional RAM or a faster processor will greatly improve the performance of the software.

The minimum hardware and system Requirements are listed here:

Computer:	PC with Pentium II 400MHz or faster
System:	Windows 98, NT, 2000 and XP
Display:	1024 by 768 pixels or higher with small font
MS Office:	Office 2000 or later version
Memory:	128 + megabytes of RAM
Disk Space:	20 MB of free disk space

II-2. Installing the Software

TADPRO is shipped on a CD containing necessary files to install the software.

Insert the ***TADPRO*** CD into CD-ROM drive. The installation program will automatically start the setup process. Follow the on-screen instructions.

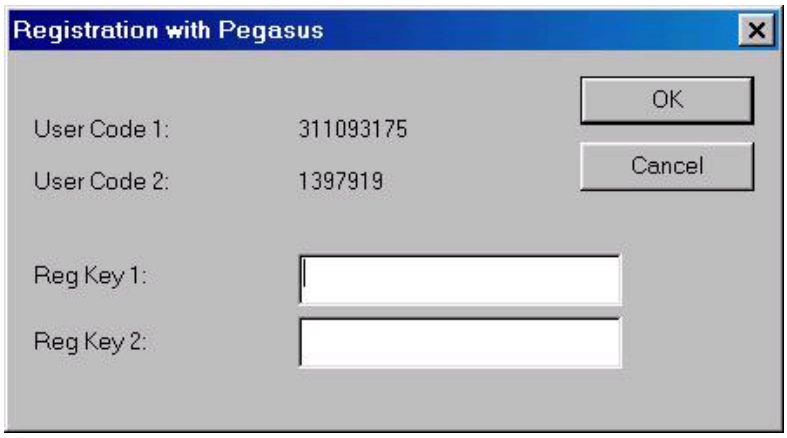
After setup, there will be a new program folder in “Programs” of Windows Start menu. It is called ***TADPRO*** and it contains ***TADPRO*** executable file.

Please go to the C:\Program Files\TADPRO folder and double click “**hdd32.EXE**” to install the drivers for the dongle. **You need to plug-in the USB dongle to run the *TADPRO*.**

II-3. Licensing the Software (for users with no USB dongle)

Select ***TADPRO*** under the ***TADPRO*** folder from the Program menu. This will launch the software.

The default mode of software is the demo mode. User can register the software with Pegasus Vertex or use the software till it expires. At this time, the licensed user should click “Register Now” button and obtain the User Code 1 and Code 2 in the following dialog box.



Then user should send the information to the following address by phone, e-mail, fax, or mail:

Pegasus Vertex, Inc.
6100 Corporate Dr., Suite 448
Houston, TX 77036
Tel: 713-981-5558; Fax: 713-981-5556
E-mail: sales@pvicom.com

Upon receiving the User Code 1 and User Code 2, Pegasus Vertex will provide the licensed user with register Key 1 and Key 2. User then can enter the register keys to activate the program.

II-4. Quick Tour

Install:

1. Insert the ***TADPRO*** CD into CD drive. The installation will start automatically.

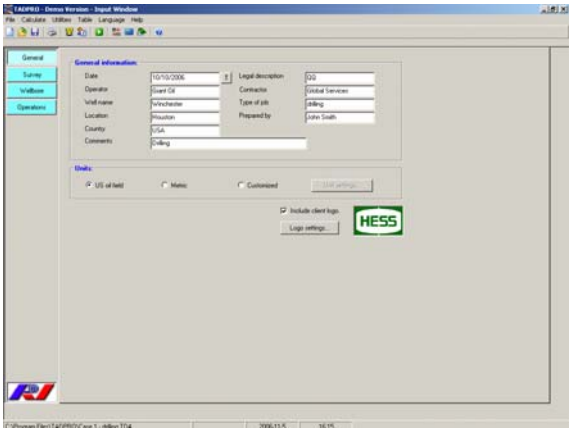
Run:

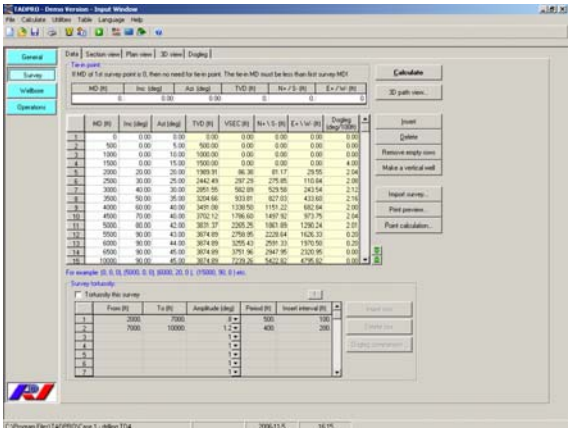
2. Double click the ***TADPRO*** icon on the desktop to lunch the program.

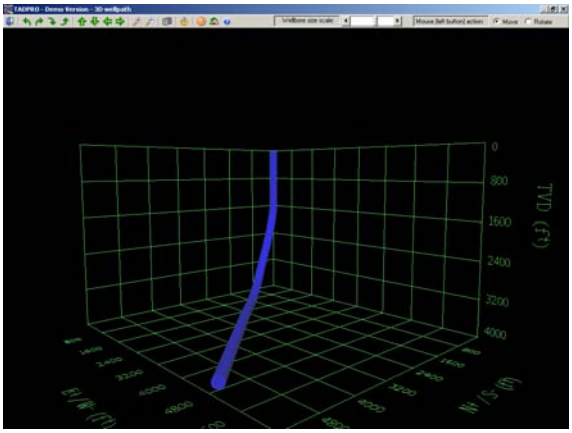
Input:

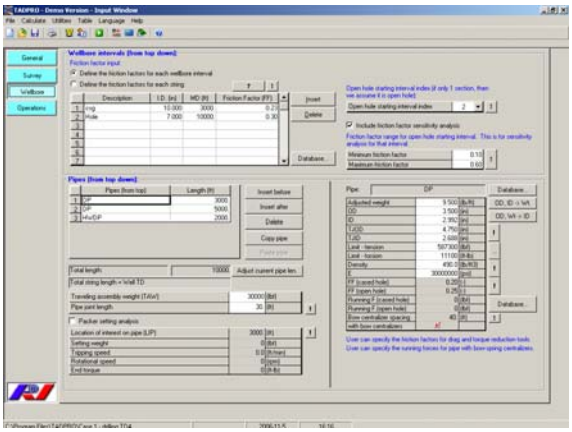
3. Choose “Open...” from the File menu and select “Case 1 - drilling.TD4”.

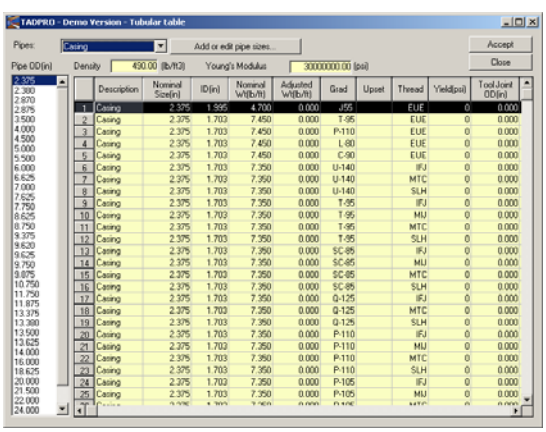
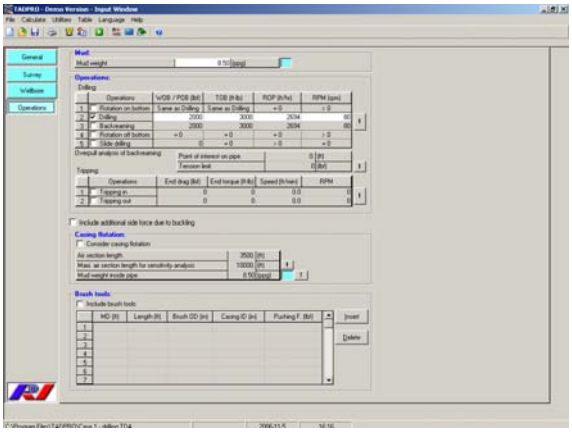
4. Review the input data by clicking the buttons on the left of Input Window and review each window content in turn (General, Survey, Wellbore, Operation). Also click the "Wellbore Schematic..." button on toolbar to view the wellbore structure for this example.







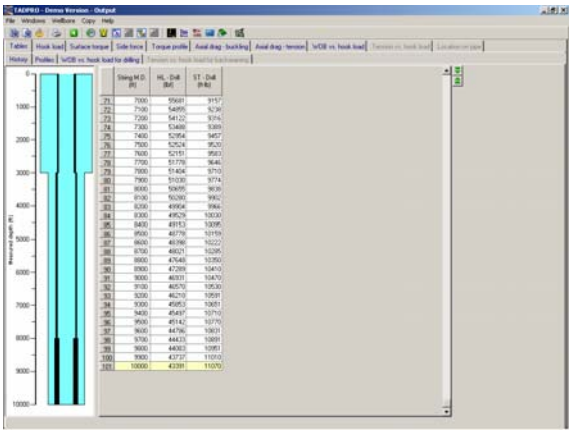
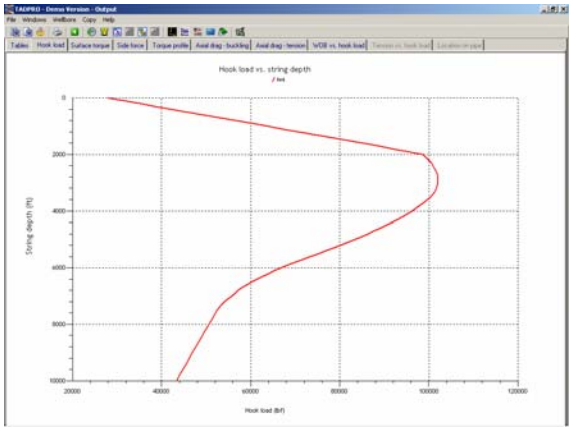
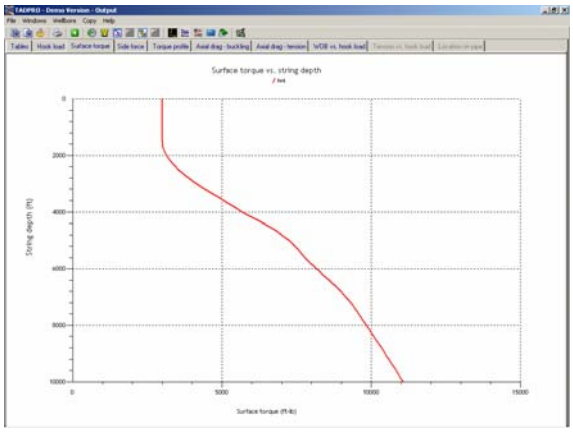
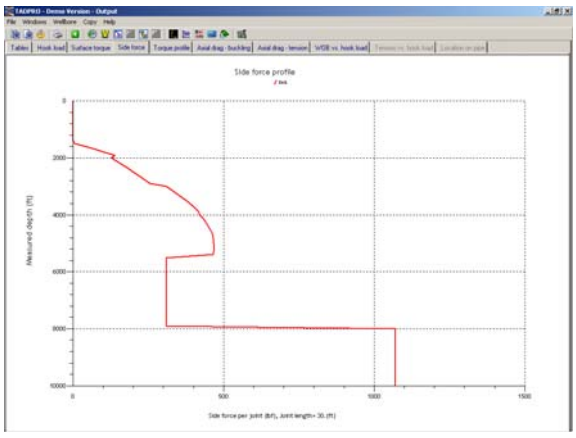


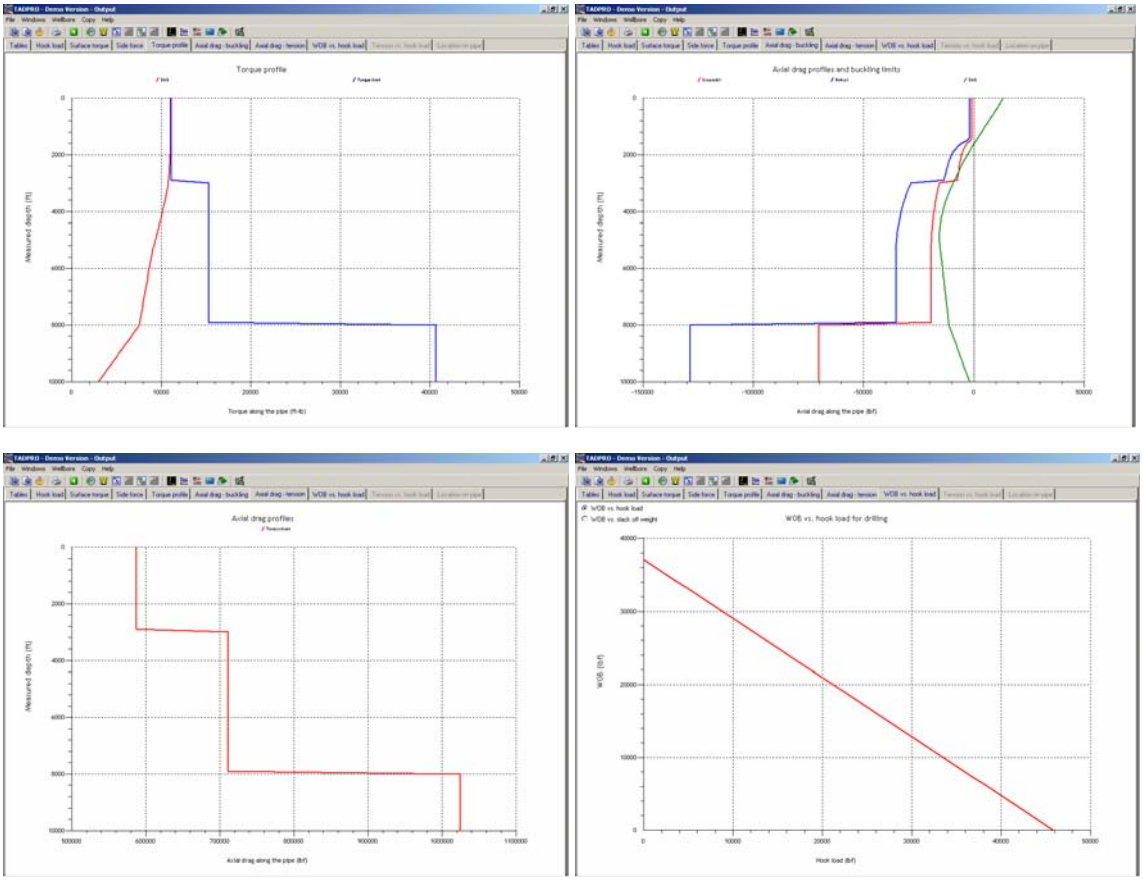



5. Click the "**>**" icon on toolbar to perform the calculation.

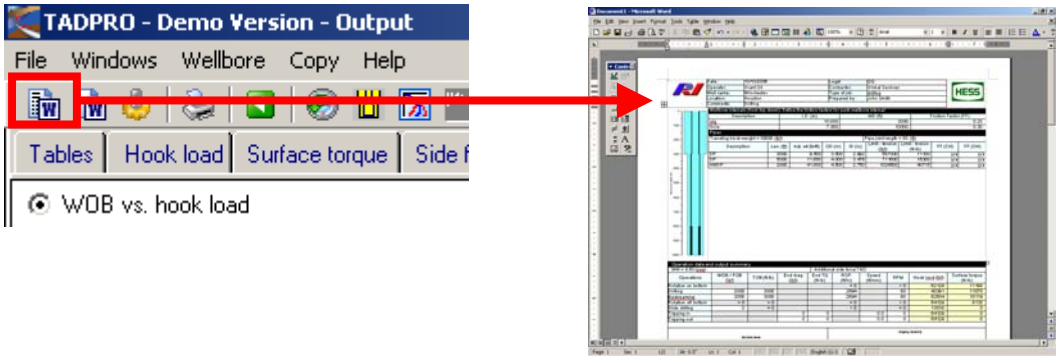
Output:

6. After calculation, the Output window is loaded as shown in the following pictures. Click different tabs to view reports and graphs.

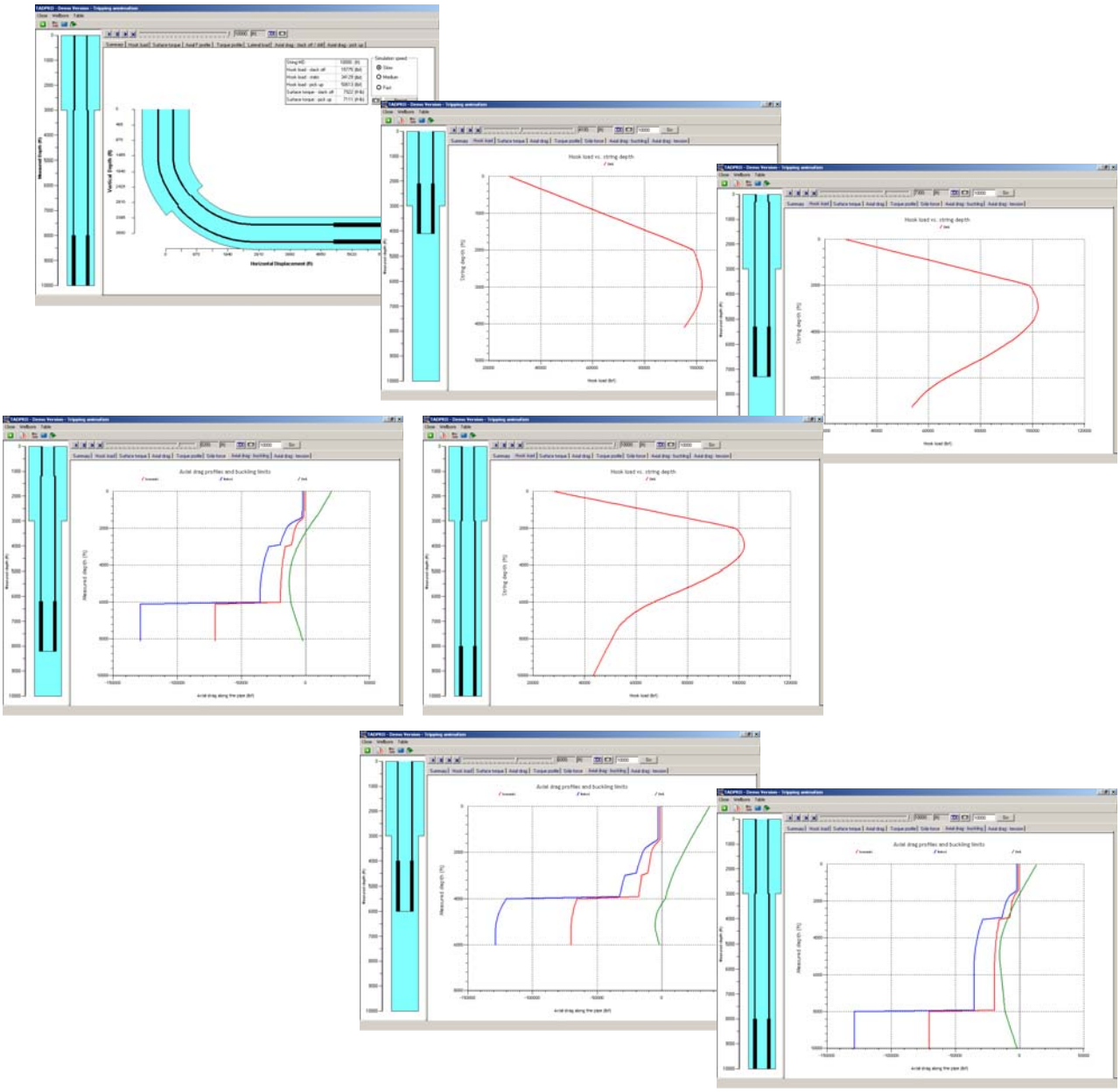







7. From File menu, select “Generate MS Word Report” to export all tables and graphs to an editable Word document.



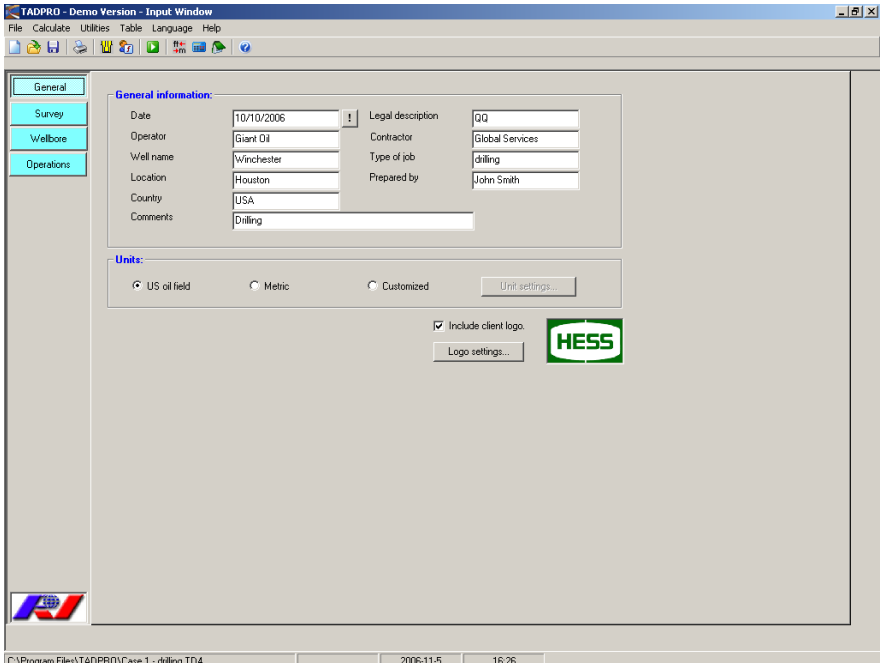
8. On the toolbar, there is a button called “Animation”. Clicking it will open “Tripping animation” window.



9. Finally, go back to the Input Window and select “Exit” from the File to close the program.

III. Input Windows

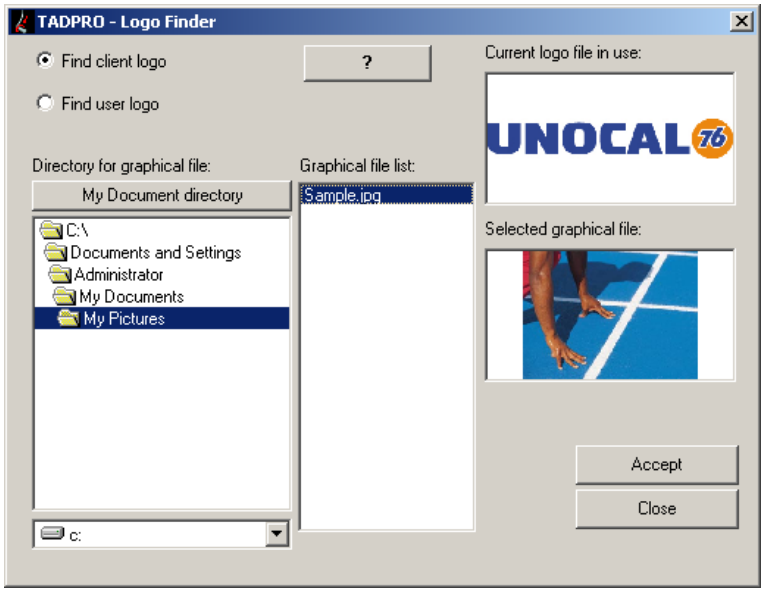
III-1. General Information



This window provides specific information about the job to identify the operator, well name, location, date, and miscellaneous comments. These items are not required and may be left blank if desired. However, they will appear in all printout for reference purpose only.

User should also select the desired system of units. The default system of units is English also called US Oil field. Once the user selects the system of units, program will keep the unit setting in the system, so next time the user open the program, it will have the same unit setting as in the previous session.

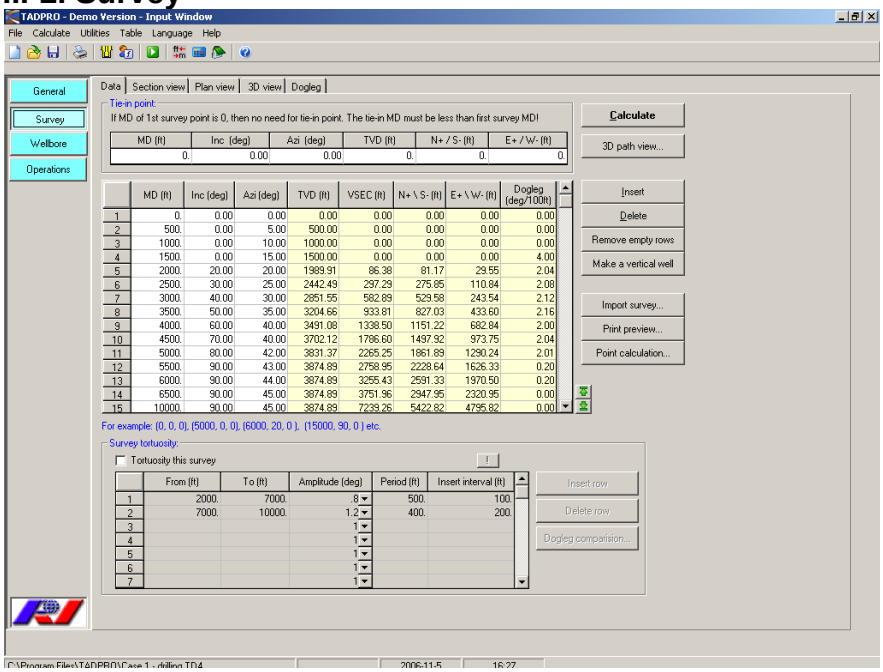
The default logo image, as shown in the low left corner, is that of Pegasus Vertex, Inc. Licensed user can put his or her own logo image into the program. Simply create your own logo file with bitmap format and save it to ***TADPRO*** folder with name "userlogo.bmp". Next time you run ***TADPRO***, your logo will appear in Input Windows and printouts. User also can choose user logo and client's logo by clicking the "Logo settings…" button on this window.



User logo represents the software licensee company. It is normally displayed in the upper left corner of most printout. This logo is a bitmap file named "userlogo.bmp" stored with the executable file. This window allows the user to browse the folders and find right graph for the user logo file.

Client logo represents the client company of software licensee. It is normally displayed in the upper right corner of most printout. This logo is a bitmap file named "clientlogo.bmp" stored with the executable file. This window allows the user to browse the folders and find right graph for the client logo file.

III-2. Survey



This window provides wellbore trajectory information.

The user may input up to 1000 survey stations. The survey depth in row 1 should be 0 feet or 0 meters. Survey depths must be in ascending order.

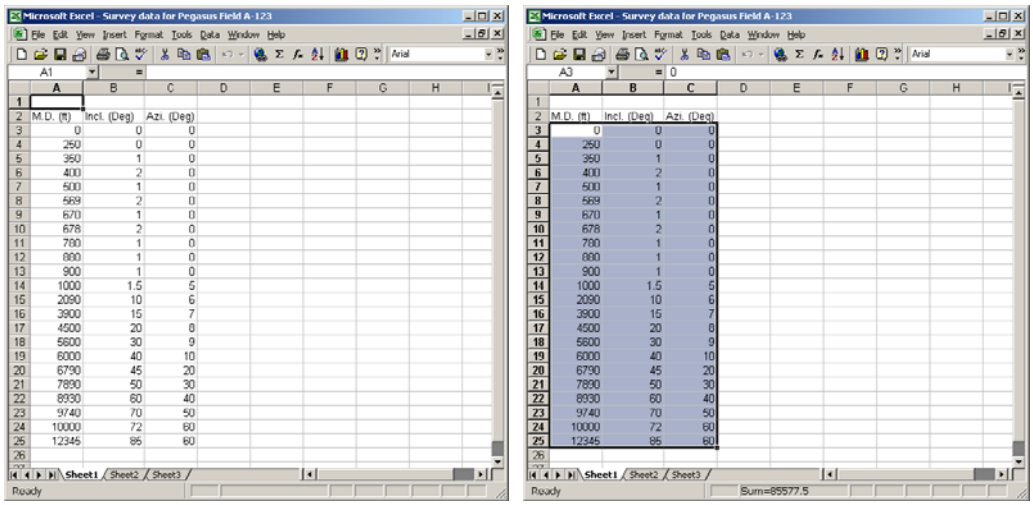
Wellbore survey data (measured depth, inclination angle and azimuth angle) are entered into the first three columns of the table. The values in other columns are calculated quantities. The yellow background on these columns denotes they cannot be entered or edited by the user.

The survey data is very important in determining the wellbore trajectory and doglegs. ***TADPRO*** not only uses the inclination angle changes, but also consider the azimuth angle change to calculate the total dogleg. The survey data directly affect the lateral load, standoff calculation.

III-2-1. Copy from Excel Spreadsheet

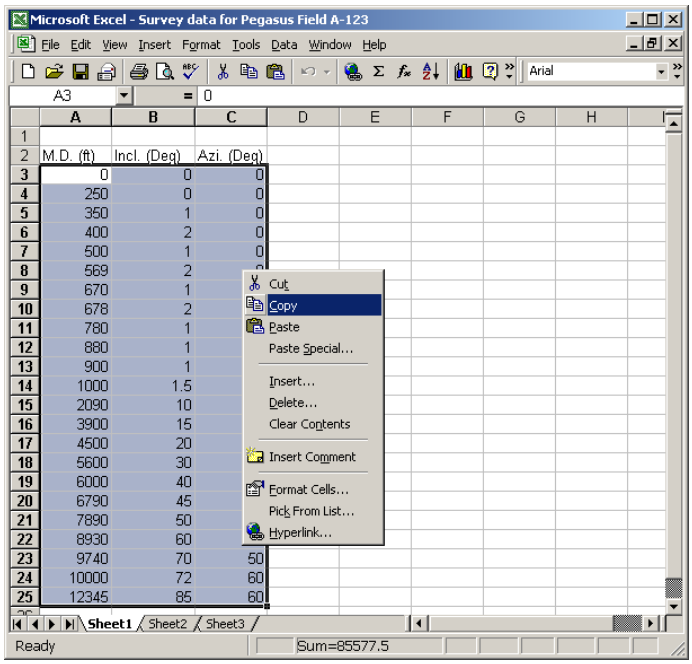
If the user has survey data in certain electronic format, he or she can easily copy the survey data from other applications such as MS Excel or Notepad into ***TADPRO*** by following these steps:

(1) Open the survey data file. We are using MS Excel for example.

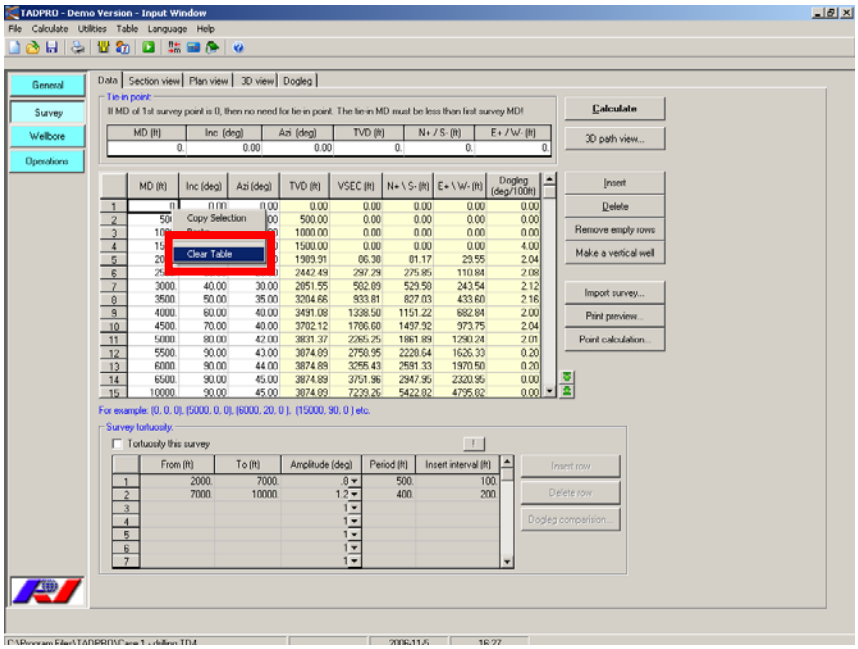


(2) Highlight the data block containing measured depth, inclination angle, and azimuth angle.

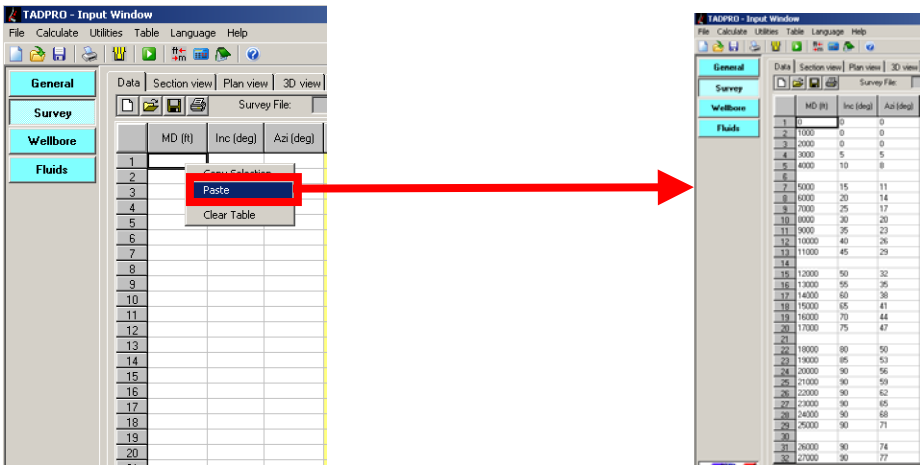
(3) Click the right mouse button while the mouse pointer is inside the highlighted area.



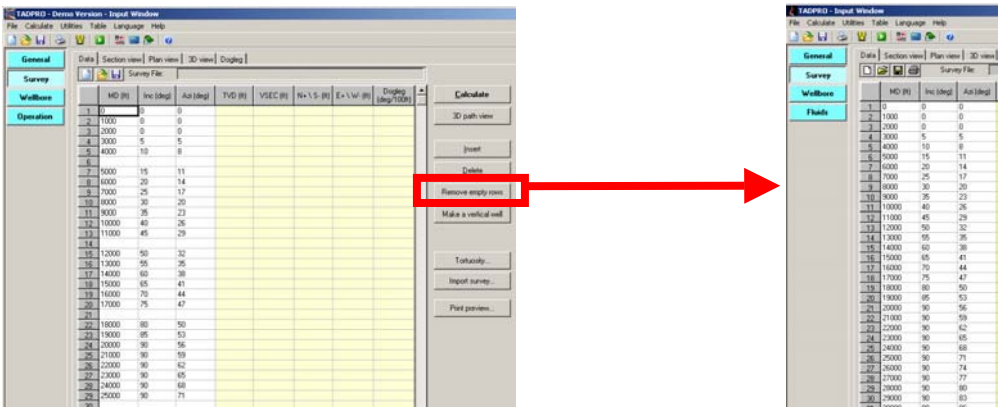
(4) Switch back to the Survey window of ***TADPRO***. Right mouse click and select “Clear table” to clear the survey table.



(5) In the blank table, click the top-left cell in the table. Then, right-click the mouse and select the “Paste” to paste the data into the survey table.

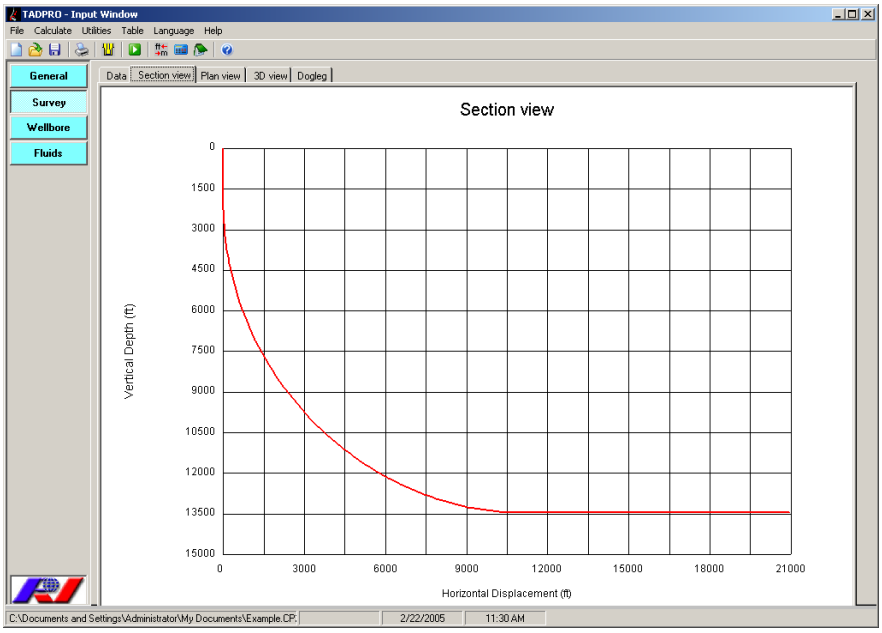


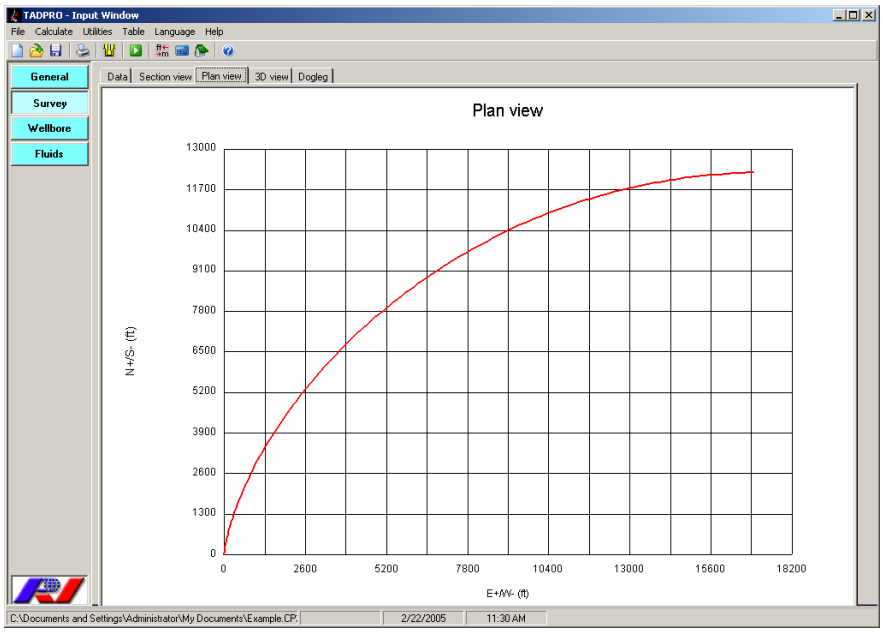
If the original survey data have blank rows, after using the above method to paste data into TADPRO, the user can simply click “Remove empty lines” button on the right of the table to remove all the empty rows. Please see the next 2 pictures for illustration.



Now that the data are pasted into ***TADPRO***, user can save the input data file. The survey data are part of the input data file.

After the survey input, the user can click “Calculate” button on the right of the survey table and view graphs on the wellbore trajectory. These graphs include (1) Plane view,(2) section view, (3) 3D view, and (4) Dogleg as shown in the following graphs:




TADPRO - Input Window
File Calculate Utilities Table Language Help
General
Survey
Wellbore
Fluids
Data Section view Plan view 3D view Dogleg
Plan view
N+/S- (ft)
E+/W- (ft)
13000
11700
10400
9100
7800
6500
5200
3900
2600
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5200
7800
10400
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15600
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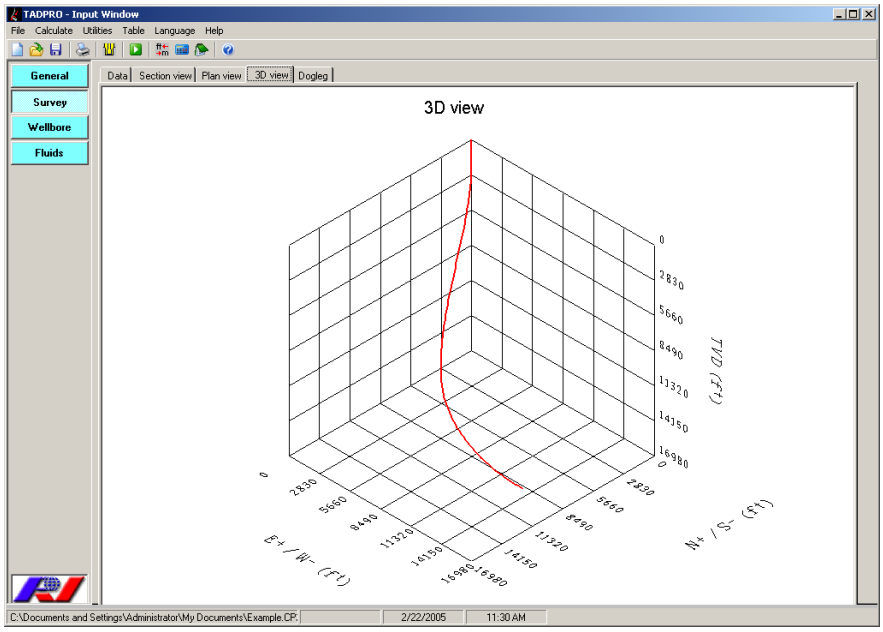
11:30 AM


TADPRO - Input Window
File Calculate Utilities Table Language Help
General
Survey
Wellbore
Fluids
Data Section view Plan view 3D view Dogleg
3D view
TVD (FT)
E+ / W- (FT)
N+ / S- (FT)
C:\Documents and Settings\Administrator\My Documents\Example.CP
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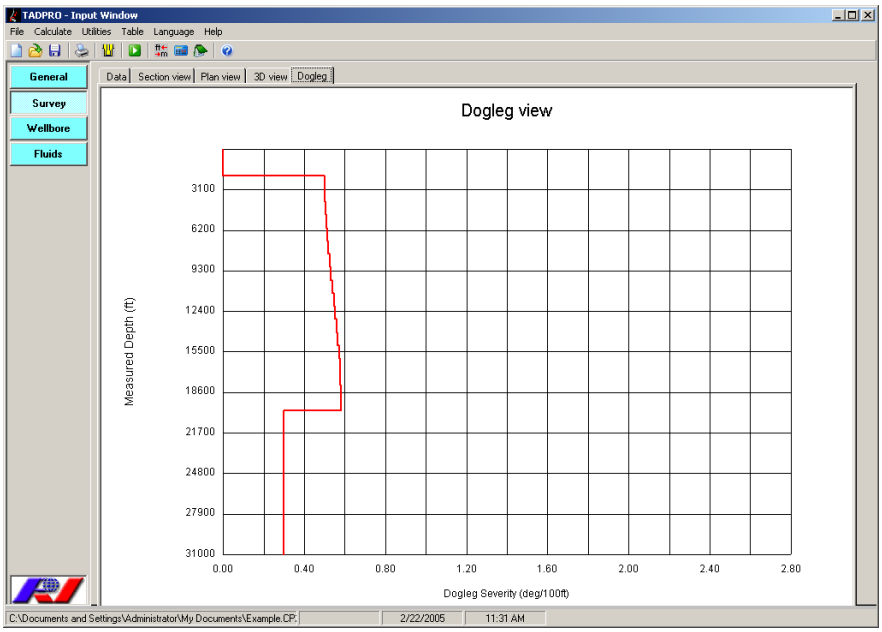
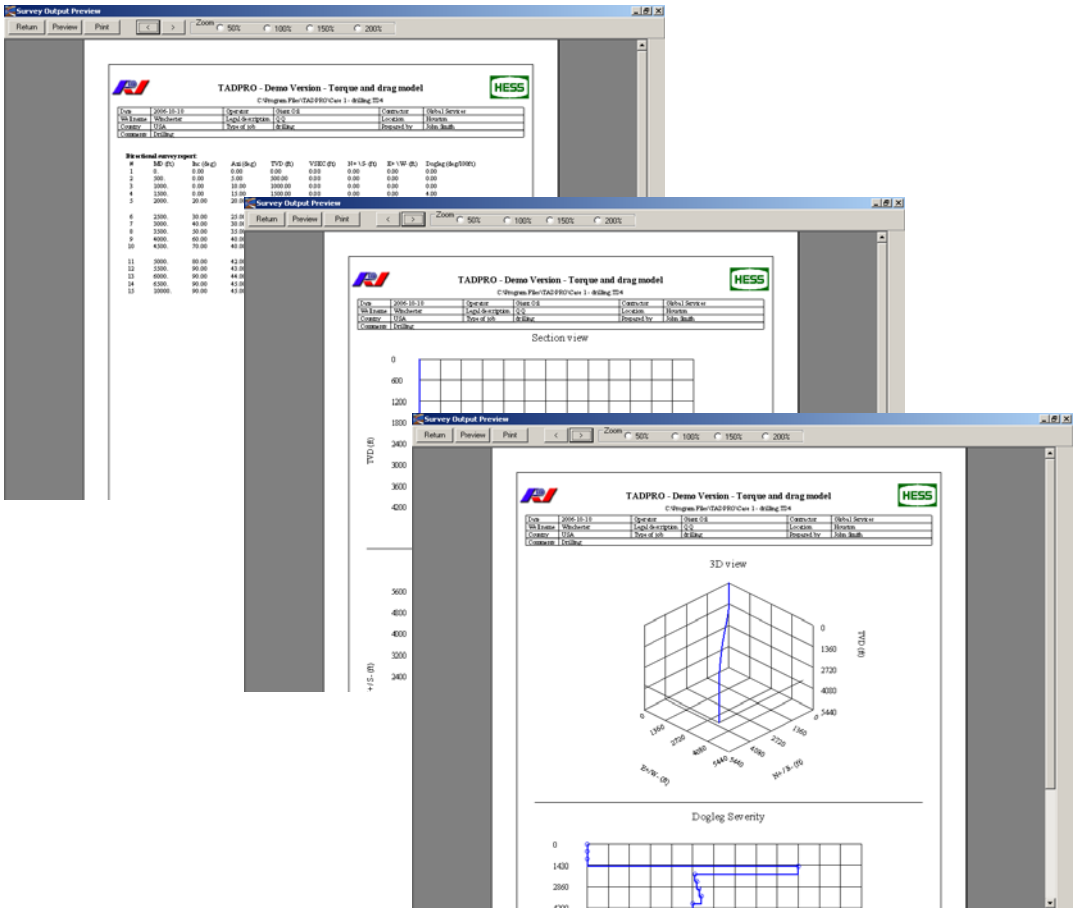
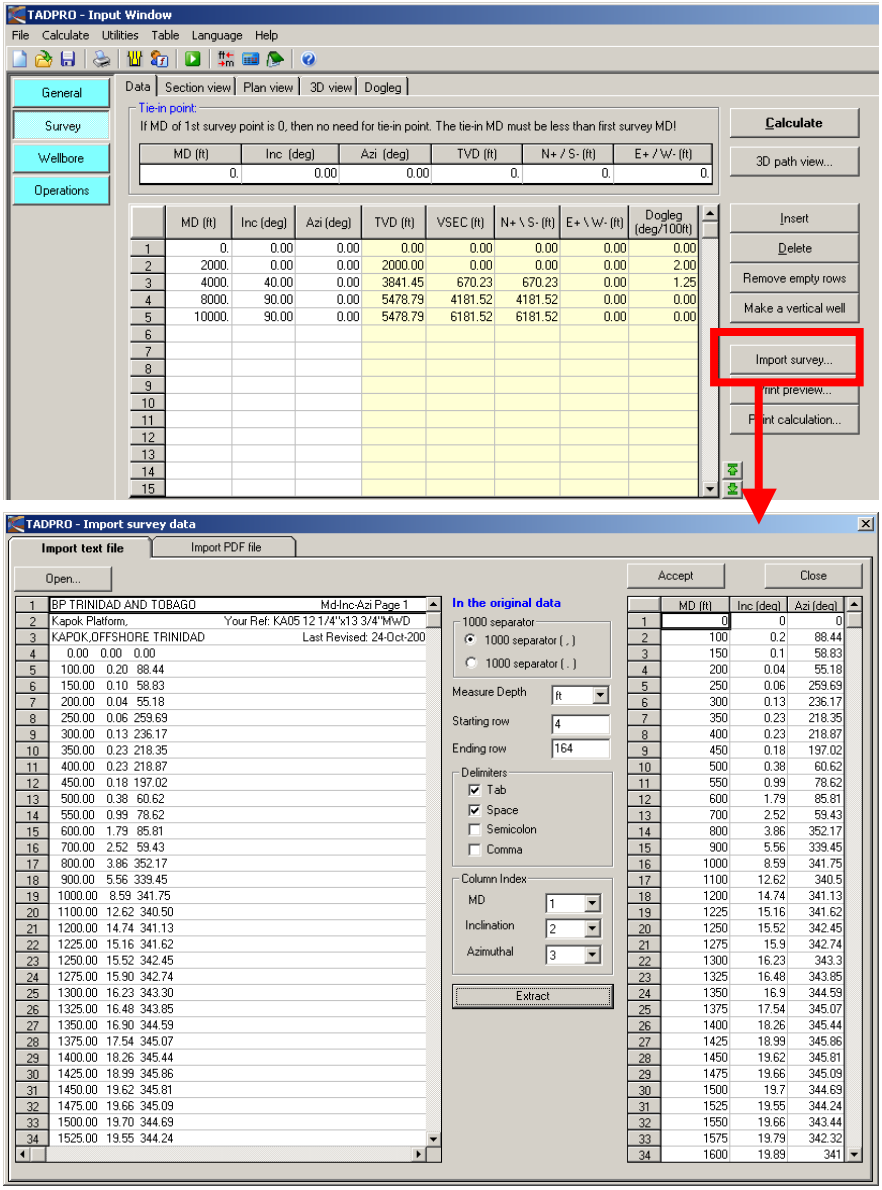


User can also preview and print out wellbore trajectory; data table and graphs by clicking the “Print survey file” button in the toolbar immediately above the survey table to preview the printouts. See the picture below.



III-2-2 Import from text file

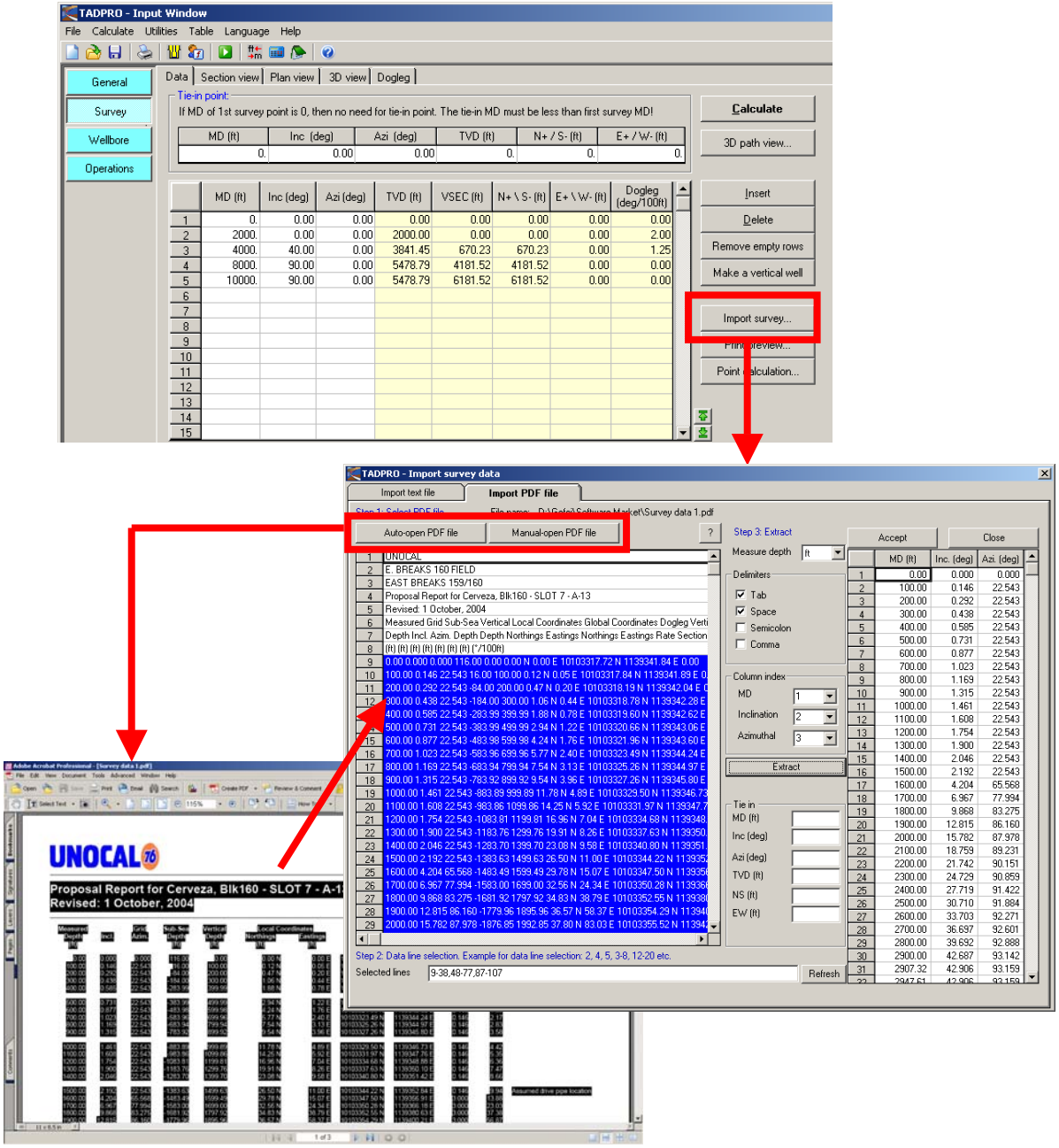
If the survey information is contained in a text file, TADPRO provides a easy way to extract survey information from it.



The benefit of this feature is that user can retrieve any survey information no matter how the data columns are separated with various delimiters.

III-2-3 Import from PDF file

If the survey information is contained in a PDF file, TADPRO provides a easy way to extract survey information from it.

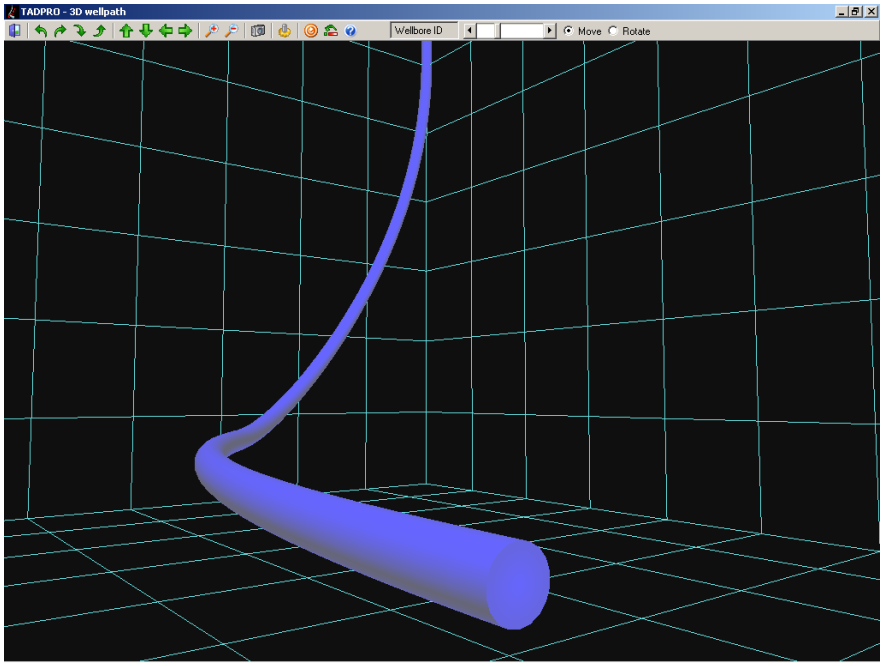


Sometimes, PDF file contains multiple pages of information. TADPRO is smart enough to select data blocks from each page and highlight them. The highlighted rows are listed at the text box at the bottom and user can change them.

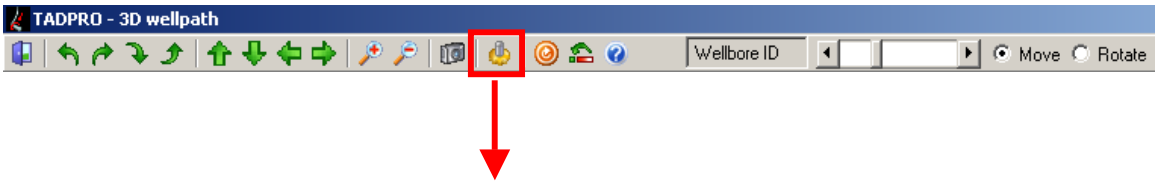
User can have 3 ways to obtain the survey data from PDF file. The 1st one is to automatically open the PDF file and let the program talk with PDF Reader. The 2nd way is to manually select the file and open it. Then, after selecting all the contents in PDF file, copy them and close the PDF file. The contents will be pasted into the table.

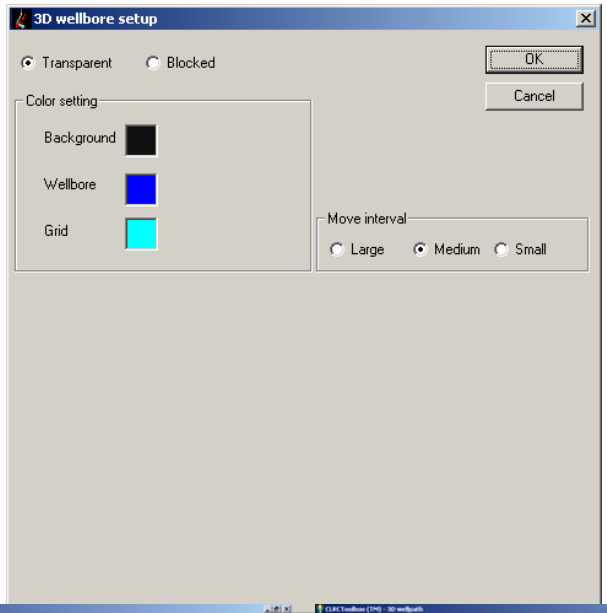
However, these 2 methods have some limitations because communicating from TADPRO with PDF Reader is not always smooth, due to various factors such as different versions of PDF Readers. So, TADPRO has another way of obtaining the data. That is called “Paste and select”. This requires the user to open a desired PDF file and select all the contents and copy them. Then, close the PDF Reader and come to TADPRO and click the “Paste and select” button. The program is smart enough to study the data pasted and highlight all the data block related to survey information.

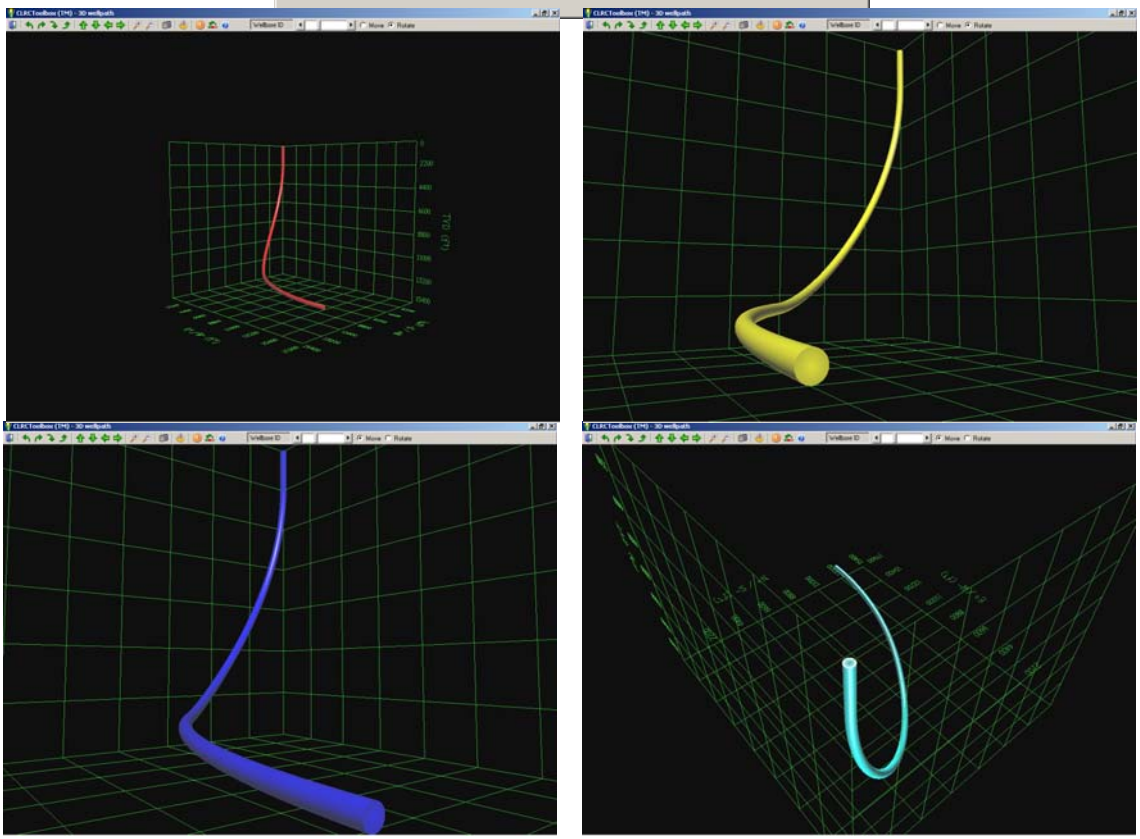
TADPRO is equipped with a feature of 3D well path visualization. After the survey data is in place, user can click the “Calculate” button to obtain the well path. Then click the “3D path view” button to open a separate window with 3D well path visualization. See the picture below.

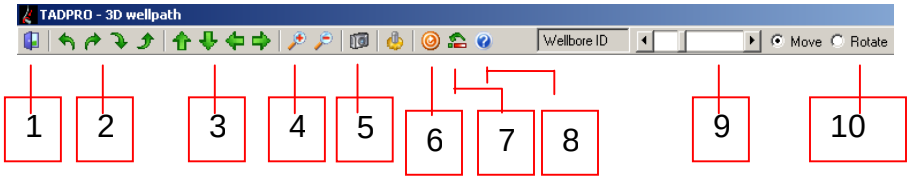


User can click the “Setup” button on the toolbar to change the way the 3D well path is presented.




3D wellbore setup
Transparent
Blocked
OK
Cancel
Color setting
Background
Wellbore
Grid
Move interval
Large
Medium
Small



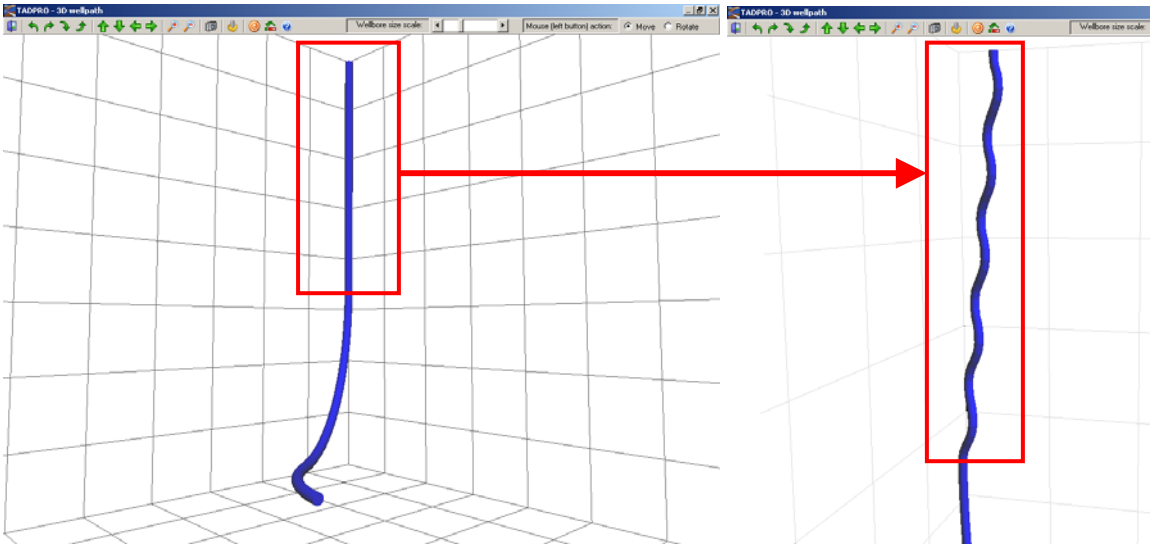


These toolbar functions are:

1. Exit the 3D well path visualization
2. Rotate the 3D graph.
3. Move the 3D graph.
4. Zoom in and out on 3D graph.
5. Capture the current screen to paste to MS Offices
6. Start to rotating the 3D well path (click the same button to stop)
7. Show the 3D well path at the default angle.
8. Help on key stroke
9. Change the representative diameter of the path
10. Select the action performed by pressing the right mouse button.

III-2-4 Survey tortuosity

For a post-analysis, the survey data from field measurement is normally known. However, at design stage, the survey data are only those points from a planned well path, which is smooth and the dogleg severities are only from the build and turn rates. To make the ideal well path (smooth) more realistic (rough), methods have been developed to apply artificial roughness “tortuosity” to smooth well path. One of the tortuosity methods is adding a sinusoidal variation to both inclination and azimuth of a planned path with certain amplitude and period. The following graph illustrates the original and tortured survey for the vertical section.

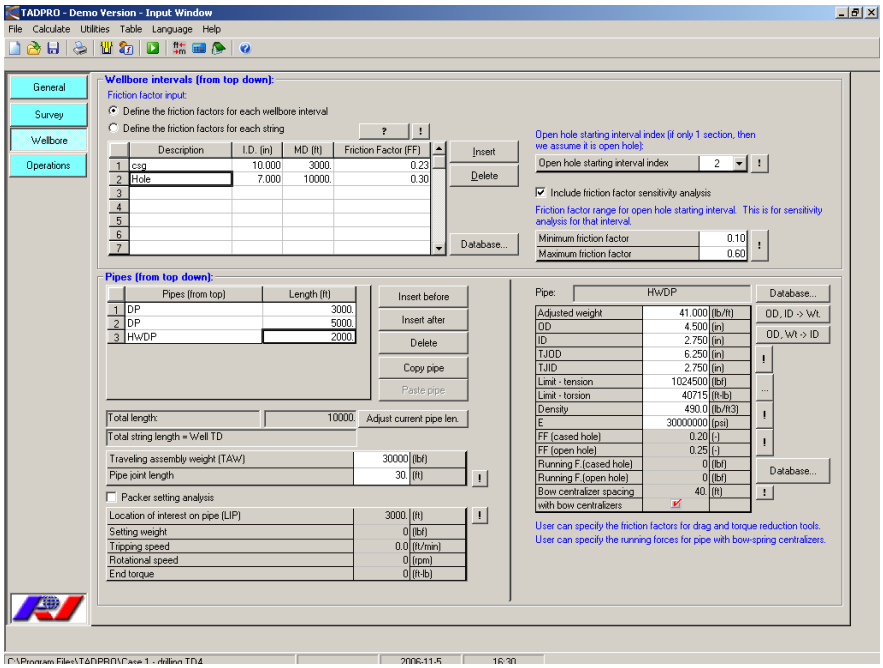


Well path tortuosity and friction factor affect the torque and drag analysis differently. While friction factor is some time used as an all encompassing "fudge factor" to take into account all unknown conditions, it has its limitations. It is necessary to use both to achieve more logic and realistic prediction.

Generally speaking, the higher friction factor will yield higher torque and drag. However, in a vertical section, the calculated normal force will be zero. At this condition, there won’t be any drag or torque variation even we increase friction factor. At this condition, friction factor will fail to act as "fudge factor" to calibrate the field measurement.

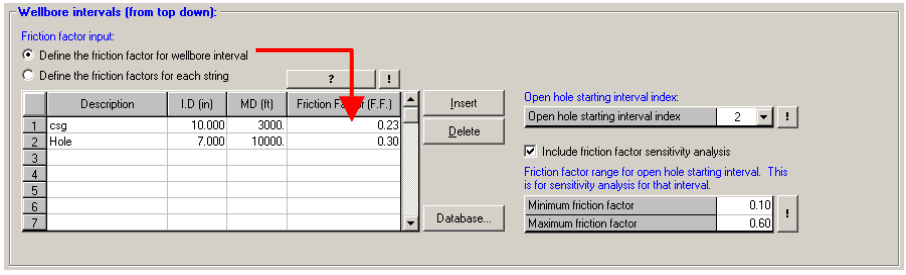
For this and more logic consideration, it is desired to torture the well path to reflect the actual drilling condition. The mathematically smooth well path is not realistic, because there is no absolute vertical well in the field. Even with the field measured survey data, sometime the points above the kick off point are not included in the survey data. It is necessary to introduce the tortuosity for different well path sections.

III-3. Wellbore



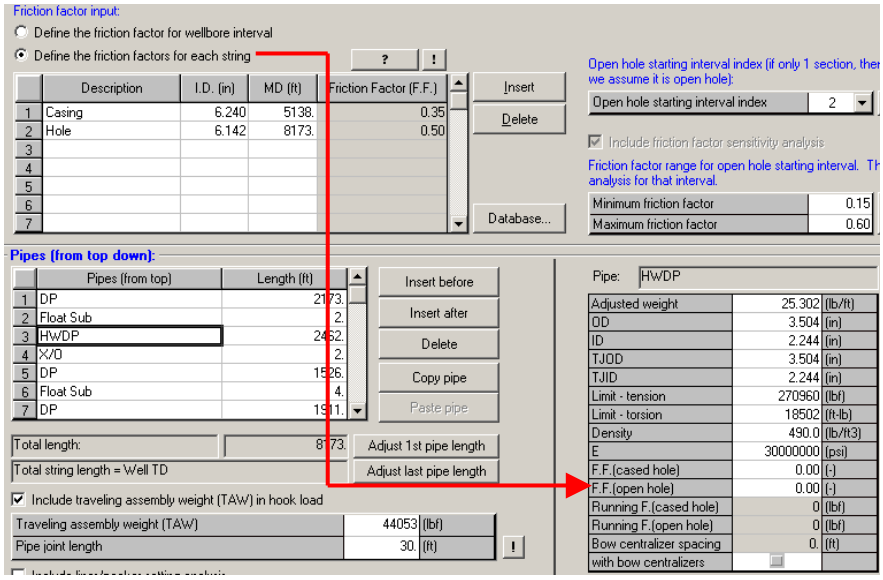
This window asks the user to input wellbore intervals, pipe configuration.

There are 2 ways of defining friction factors: with wellbore intervals or with each pipe section.



If the user chooses to specify the friction factor for wellbore intervals, he needs to input these values together with interval description, ID and bottom measured depth. Up to 20 different wellbore intervals can be specified. If casing ID is unknown, click the "Database" button beside the table to open the Tubular database window. Note that the wellbore intervals are input from top down.

User can also choose to input the friction factor for each string. This is to consider the situation when special drag or torque reduction tools (with low FF) are installed on certain pipe components. In this case, program needs to know the FFs for cased and open hole section for that pipe. Program will keep tracking of the locations of each pipe and calculate the torque and drag accordingly, because the pipe with tool is moving along the well and it is necessary to know how long the pipe is in cased hole and how long is in open hole intervals.



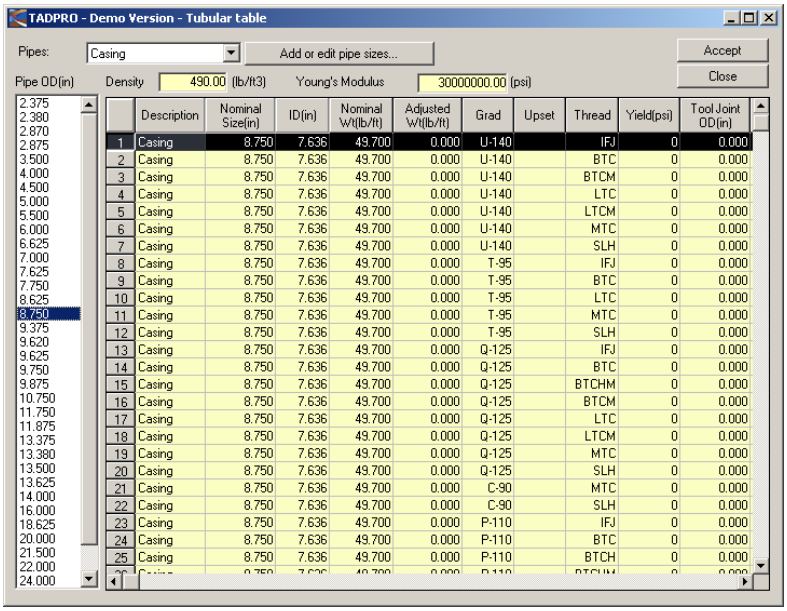
Below the wellbore interval table is the pipe list table. The first row in the table is the top section of all pipe components. User inputs other sections of pipe from top down. For example, when running liner using a drill pipe, the top row will be for drill pipe, and the bottom row will be for liner itself, as shown in above picture.

TADPRO can handle up to 50 different pipe components. User can specify the pipe properties for that particular pipe component (the one with black rectangular box in the pipe list table).

In the pipe list table, user needs to give a description and the section length of each pipe component. Program requires that the total length of pipes equals to wellbore TD, i.e. the measured depth of the last wellbore interval in Wellbore Window. To assist the user to calculate the corresponding section length, ***TADPRO*** has a button “Adj. current pipe len.” If user clicks this button, the program will modify the section length of the current pipe component so that the total length of all pipes equals to the well TD.

The traveling block weight is the weight that is subtracted from hook load to derive actual string weight.

Pipe dimensions can be entered directly into the pipe property table or utilizing the database "Database..." button, clicking which will open an extensive on-line database of drill-string, casing and tubing

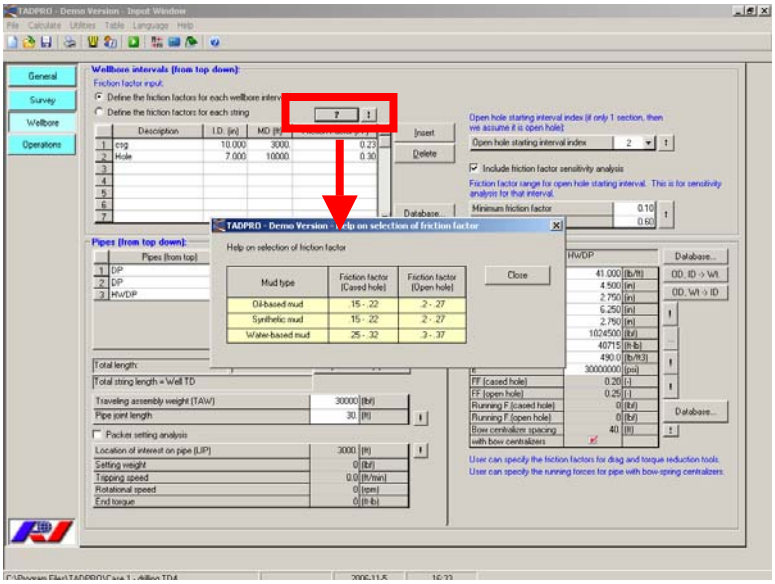


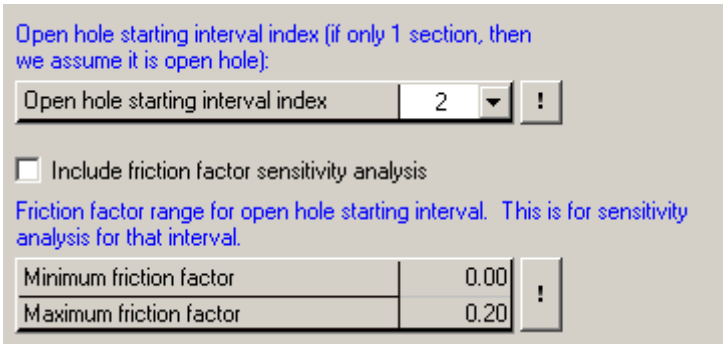
Choose the desired one and click "Accept" to place dimensions in Input Window.

Once user finishes the wellbore and pipe input, he could click the "Wellbore schematic" button on toolbar to view the wellbore schematic. See "Wellbore Schematic" in "Input Windows" for details.

At various places in Input Window, there are small buttons with caption “!”. These are “quick-fill” buttons, which allows the user to quickly fill certain cells with default values.

User can click the “?” button above the wellbore interval table to get the suggestions on friction factor selection.





This window also asks for "open hole starting interval index". This input serves 3 purposes:

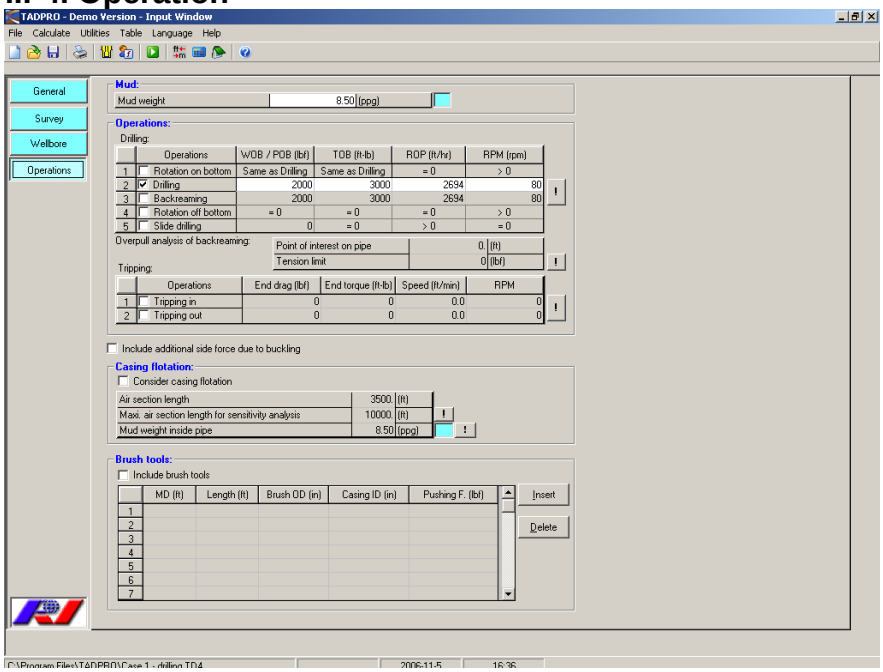
(1) Friction factor (FF) sensitivity analysis – Normally, FF for cased hole can be estimated, but the FFs for open hole intervals are more difficulty to determine. To perform sensitivity analysis for FF, program needs to know the interval to vary the FF. This index is used for this purpose.

(2) Friction factor (FF) Calibration – This feature is illustrated in III-5. Fraction Factor (FF) Calibration. To perform FF Calibration, program needs to know the interval to vary the FF. This index is used for this purpose.

(3) Define FF for each string – TADPRO allows the user to either input the FF for wellbore intervals or for each string. For the 2nd option, TADPRO will ask the user to input the 2 FFs for each string, one for cased hole, one for open hole. This index is used to let the program know the starting intervals of open hole intervals.

Note that friction factor is the representation of the friction between the wellbore/casing and the drill string. It is dependent on (1) mud type, (2) contact surfaces (formation type or tool joint material), (3) cutting concentration, and other conditions.

III-4. Operation



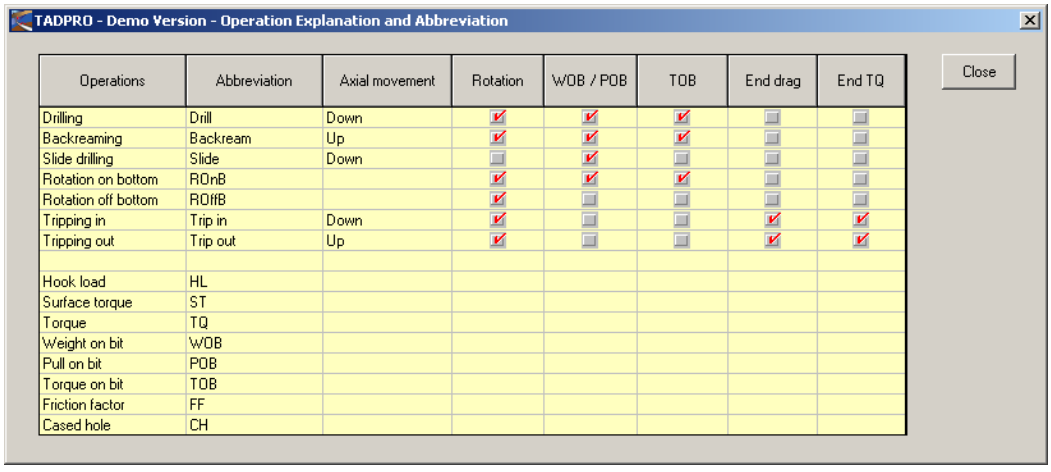
This window allows the user to define the fluids in the wellbore system and operation parameters.

Mud weights affect buoyancy of the drill string and hook load at surface. User can change the colors of fluids inside and outside of pipes. These colors will be used in the pipe tripping animation.

TADPRO simulates the following 7 operations:

(1) Drilling (2) Back reaming
(3) Slide drilling (4) (4) rotation on bottom
(5) rotation off bottom (6)Tripping in (7) Tripping out

The explanations of these operations and some abbreviations can be found in “Abbreviation…” under Help menu.



Operations	Abbreviation	Axial movement	Rotation	WOB / POB	TOB	End drag	End TQ
Drilling	Drill	Down	☑	☑	☑	☐	☐
Backreaming	Backream	Up	☑	☑	☑	☐	☐
Slide drilling	Slide	Down	☐	☑	☐	☐	☐
Rotation on bottom	ROnB		☑	☑	☑	☐	☐
Rotation off bottom	ROffB		☑	☐	☐	☐	☐
Tripping in	Trip in	Down	☑	☐	☐	☑	☑
Tripping out	Trip out	Up	☑	☐	☐	☑	☑
Hook load	HL						
Surface torque	ST						
Torque	TQ						
Weight on bit	WOB						
Pull on bit	POB						
Torque on bit	TOB						
Friction factor	FF						
Cased hole	CH						

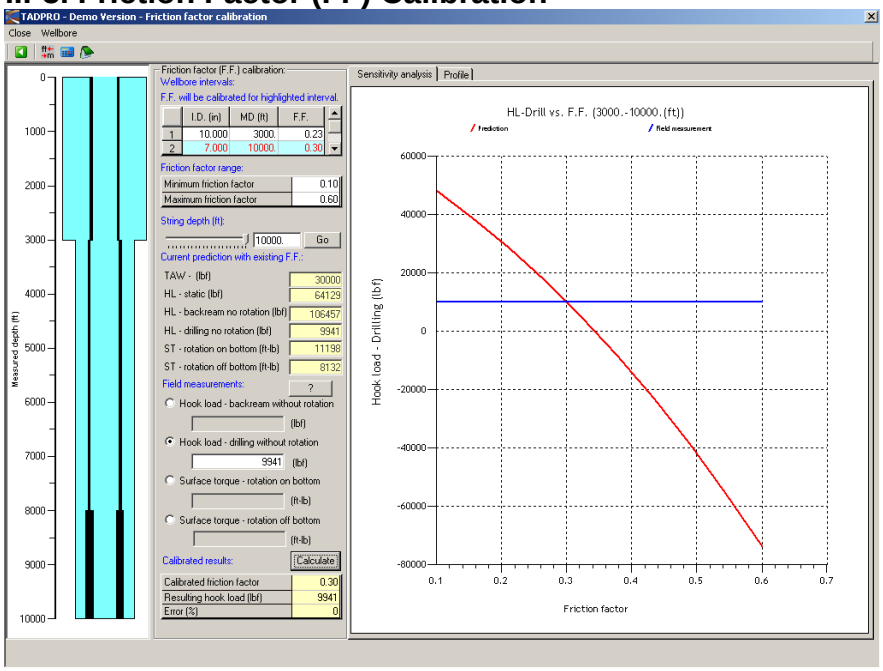
The pipe end drag and torque are the operational parameters and loads at the bottom of the pipes. These values are primarily associated with stabilizers or logging tools. They are used as the bottom boundary conditions, from which the torque and drag are calculated upward along the drill string in sections.

To simulate drilling operations, specify the weight on bit and torque on bit.

If the casing flotation is used, the user can click the “Consider casing flotation” check box and input the desired air section length. “Maxi. air section length” is used to obtain the sensitivity of hook load to various air section lengths.

If there are brushes attached on pipe, TADPRO calculates the brush pushing force and rotating torque associated with these tools. User needs to input the necessary lab testing parameters.

III-5. Friction Factor (FF) Calibration



Under the Calculate menu, there is a menu item called “Friction factor (FF) calibration”. Clicking it will open the above window.

Friction factor (FF) calibration methods:

(1) From hook load of drilling without rotation

(2) From hook load of backreaming without rotation

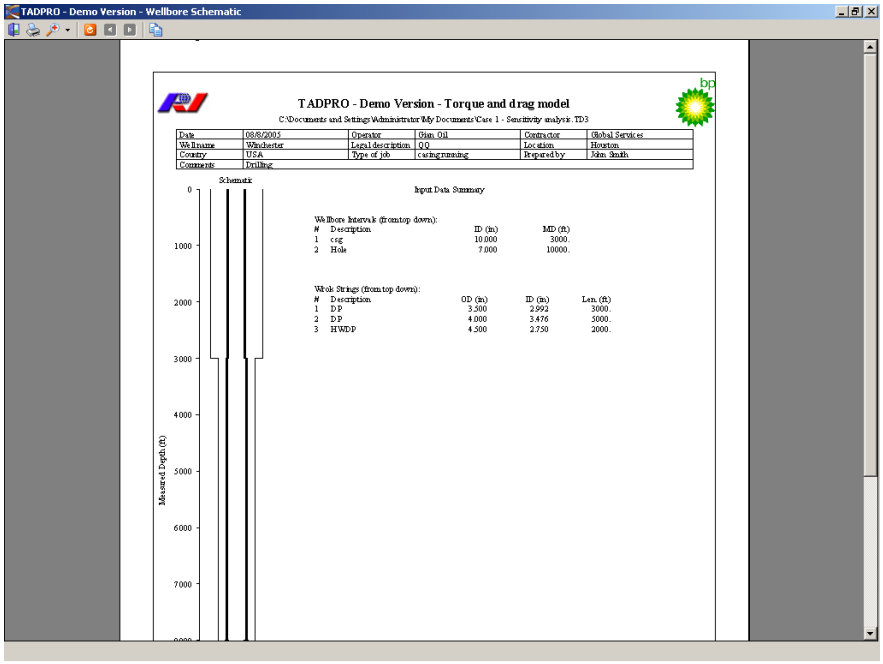
(3) From surface torque of rotation on bottom

(4) From surface torque of rotation off bottom

User can pick up a string depth and use one of the above methods to determine the friction factor in a particular wellbore interval, normally being the open hole section.

III-6. Wellbore Schematic

Once user finishes the wellbore and pipe input, he can click the "Wellbore schematic" button on toolbar to view the wellbore schematic.



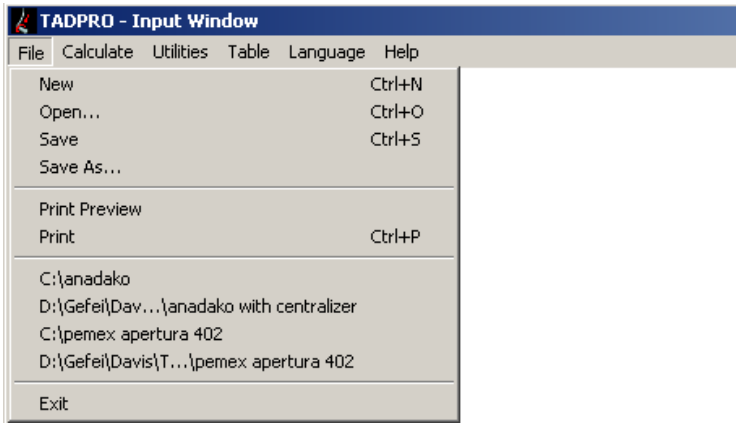
Wellbore Schematic allows the user to view the input data graphically. User can zoom-in the picture and copy or print it.

III-7. Menu

You can use menus and toolbars to give ***TADPRO*** instructions about what you want to do.

A menu displays a list of commands. Menus are located on the menu bar at the top of the window. The menu system in ***TADPRO*** is typical of Windows applications. Most functions are self-explanatory as shown in the following picture. There are 5 menus available in Input Window:

File Menu



The File menu contains commands for creating, retrieving, saving and printing input data and quick retrieval of previously opened files. The functions of the individual menu items are:

1. "New" clears all input entries for creating a new data file.

2. "Open..." opens a dialog box for exploring the file system for ***TADPRO*** input data files with the extension “CP2”.

3. "Save" replaces the existing input data file with the current input data as shown on the screen. No prompt is given before overwriting the existing file.

4. "Save As..." saves the current input data under a different file name. A dialog box is opened to let the user specify the drive, directory, and name of the input data file. Program supports long file name.

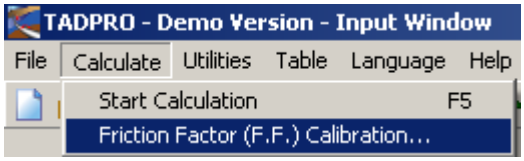
5. "Print Preview" shows the preview of the printout of the input data.

6. "Print" prints the current input data file on the default printer. To select another printer, choose from “Print Setup...” dialog box.

7. Menu items below "Print" represents recently used files, which you have most recently opened in this program. Click to quickly reopen one of these files.

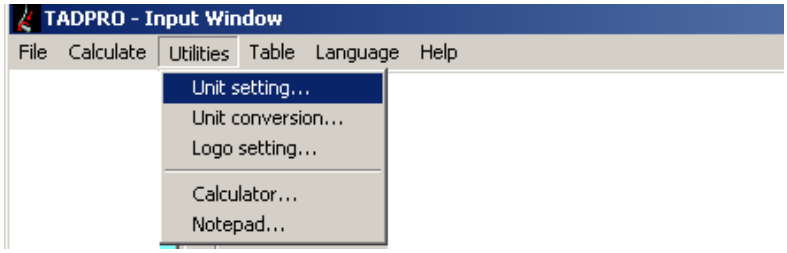
8. "Exit" closes this program after prompting you to save any unsaved files.

Calculate Menu



The Calculate menu is used to launch ***TADPRO*** calculations or perform friction factor calibration. Click “Start calculation” after all input data are entered.

Utilities Menu



The Utilities menu includes:

1. "Unit setting..." opens the Unit Setting window for selecting standard English or metric units, or a combination of English and metric units.

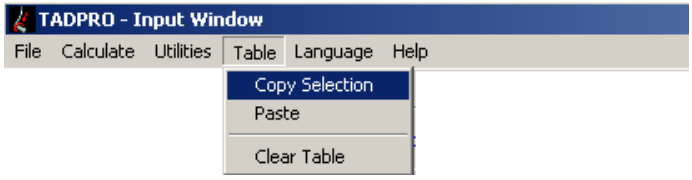
2. "Unit conversion..." opens the Unit Conversion window for converting between different unit.

3. "Logo setting..." opens logo selection window.

4. "Calculator…" launches Windows' standard calculator application.

5. "Notepad…" launches Windows' standard Notepad application.

Table Menu



The Table menu is used to perform editing functions for various tables in the program.

Language Menu

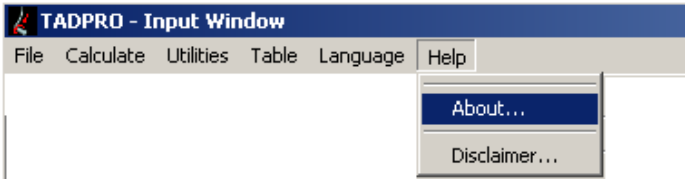
The language menu includes:

1. "English" sets all captions in English.

2. "Chinese" sets all captions in Chinese (under development).

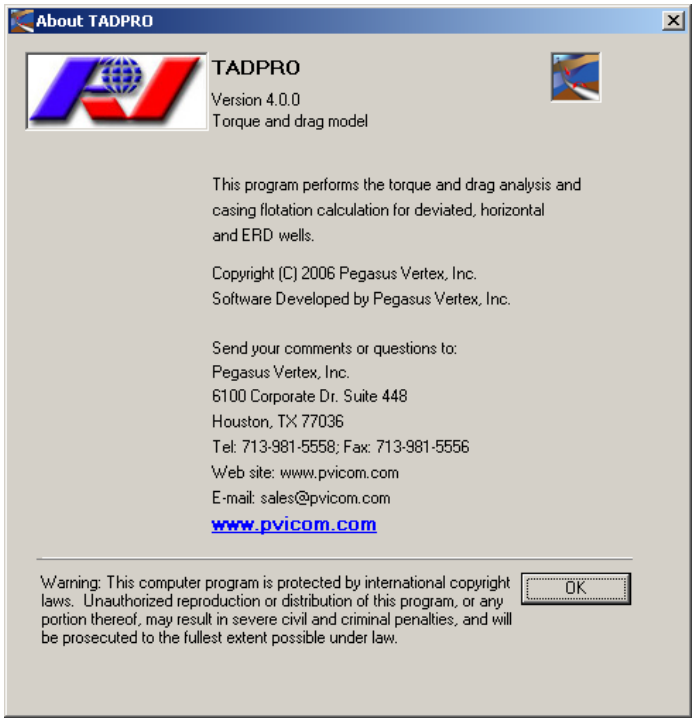
3. "Spanish" sets all captions in Spanish (under development).

Help Menu

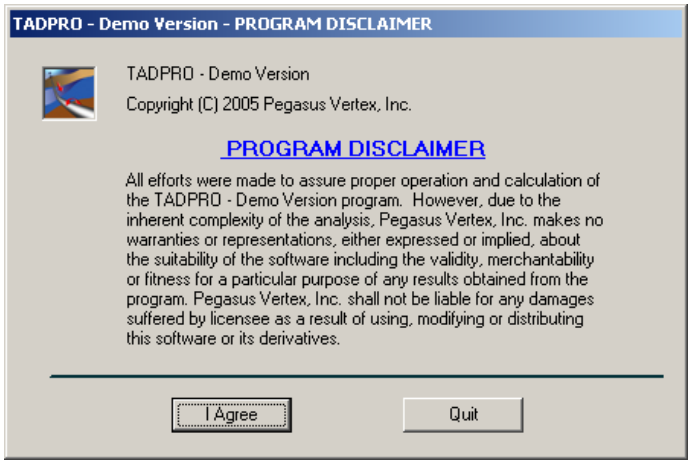


The Help menu provides on-line assistance for running the software.

1. "About..." opens the About window, which displays the version number and other information of TADPRO along with your computer hardware information.



2. "Disclaimer..." displays the program disclaimer.

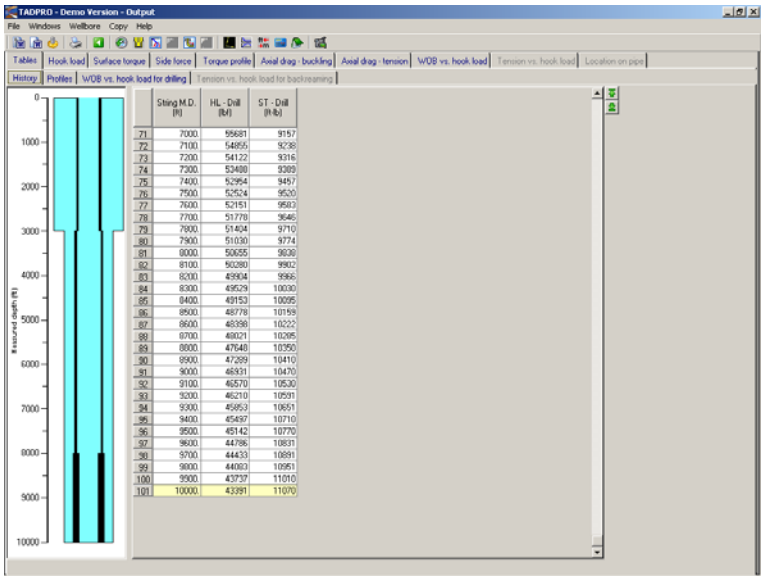


IV. Output Windows

IV-1. Reports

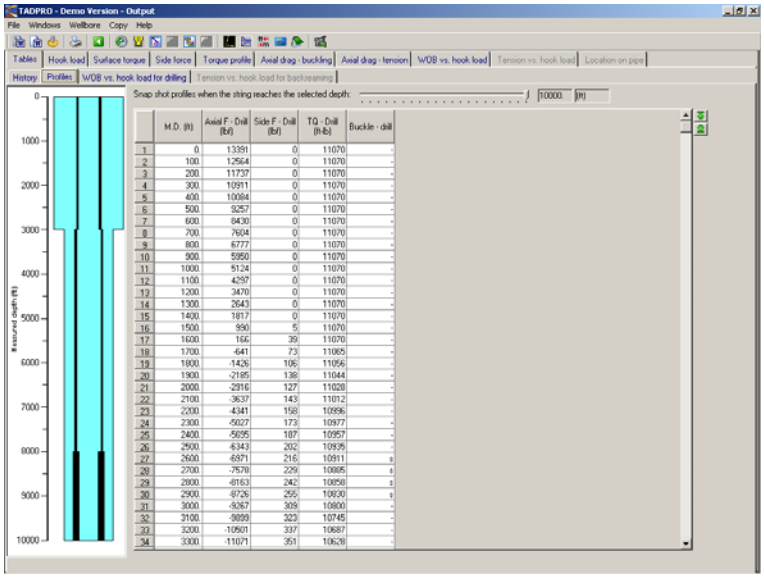
(1) Report – History

The history report displays the hook load and surface torque at different string depths for slack off, rotation off bottom (ROB) or static and pick up operations.



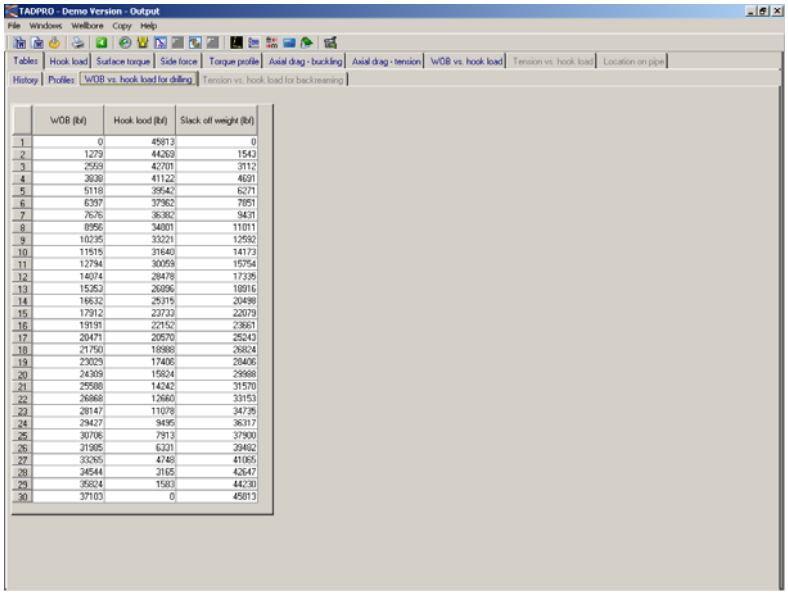
(2) Report – Profiles

In the next tab under “Tables”, user can view the force and torque profile along the pipe at various string depths by moving the sliding bar.



(3) WOB vs. hook load for drilling

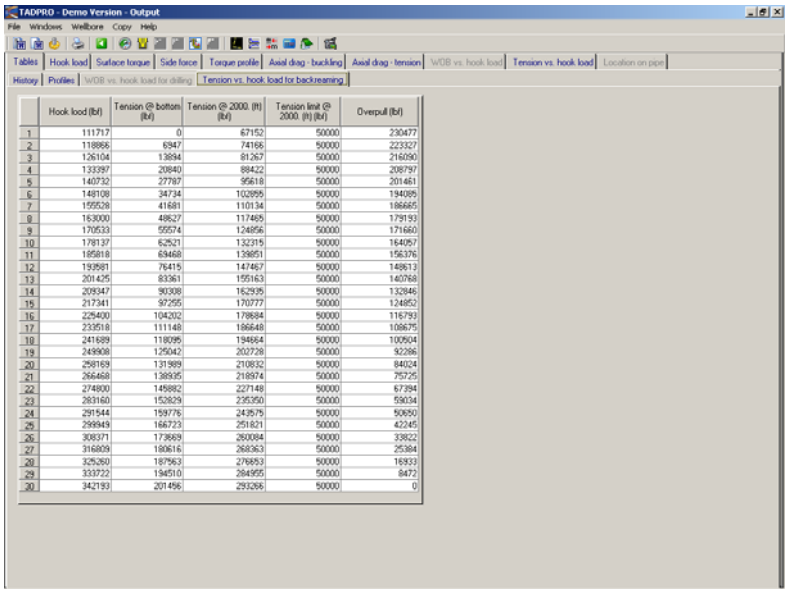
This table shows the relationship of hook load and WOB for a particular drilling condition. This shows the overall drillibility of the well.



	WOB (lbf)	Hook load (lbf)	Slack off weight (lbf)
1	0	45813	0
2	1279	44269	1543
3	2559	42701	3112
4	3838	41122	4691
5	5118	39542	6271
6	6397	37962	7851
7	7676	36382	9431
8	8956	34801	11011
9	10235	33221	12592
10	11515	31640	14173
11	12794	30059	15754
12	14074	28478	17335
13	15352	26896	18916
14	16632	25315	20498
15	17912	23732	22079
16	19191	22152	23661
17	20471	20570	25243
18	21750	18988	26824
19	23029	17406	28406
20	24309	15824	29988
21	25588	14242	31570
22	26868	12660	33153
23	28147	11078	34735
24	29427	9495	36317
25	30706	7913	37900
26	31985	6331	39482
27	33265	4748	41065
28	34544	3165	42647
29	35824	1583	44230
30	37103	0	45813

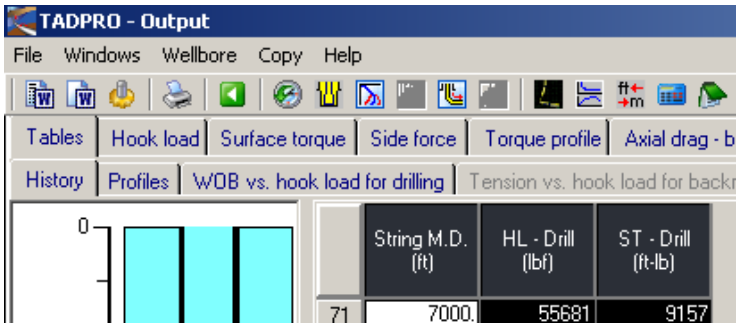
(4) Tension vs. hook load for backreaming

This table shows the relationship of hook load and tension at bottom and at particular point on the pipe. This assumes that the pipe is stuck at the bottom and you start to pull the pipe at the surface.

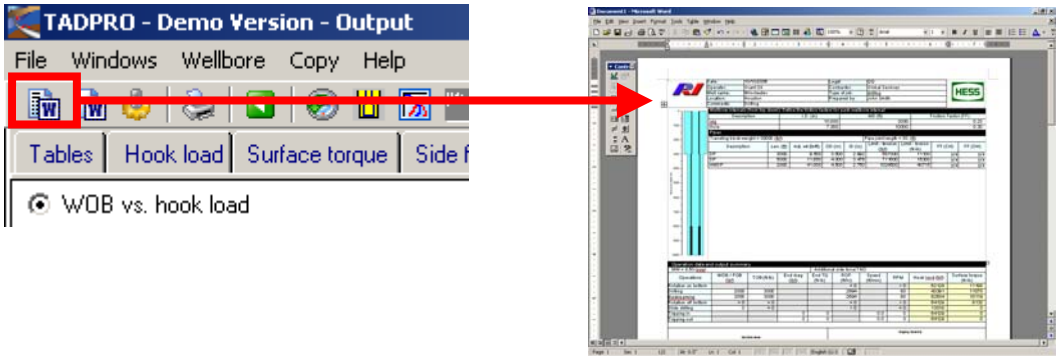


	Hook load (lbf)	Tension @ bottom (lbf)	Tension @ 2000. (ft) (lbf)	Tension limit @ 2000. (ft) (lbf)	Overpull (lbf)
1	111717	0	67152	50000	230477
2	118866	6947	74166	50000	223327
3	126104	13894	81267	50000	216090
4	133397	20840	88422	50000	208797
5	140732	27787	95618	50000	201461
6	148108	34734	102865	50000	194085
7	155528	41681	110134	50000	186665
8	163000	48627	117465	50000	179193
9	170533	55574	124856	50000	171660
10	178137	62521	132315	50000	164057
11	185818	69468	139851	50000	156376
12	193581	76415	147467	50000	148613
13	201425	83361	155163	50000	140768
14	209347	90308	162939	50000	132846
15	217341	97255	170777	50000	124852
16	225400	104202	178684	50000	116793
17	233518	111148	186648	50000	108675
18	241689	118095	194664	50000	100504
19	249908	125042	202728	50000	92286
20	258169	131989	210832	50000	84024
21	266468	138935	218974	50000	75725
22	274800	145882	227148	50000	67394
23	283160	152829	235350	50000	59034
24	291544	159776	243575	50000	50650
25	299949	166723	251821	50000	42245
26	308371	173669	260084	50000	33822
27	316809	180616	268363	50000	25384
28	325260	187563	276653	50000	16933
29	333722	194510	284955	50000	8472
30	342193	201456	293266	50000	0

All tables can be selected and copied. To copy the entire or certain portion of the table, highlight the corresponding table and click the right mouse button. The pop-up menu item called “Copy selection in the table” will show up. Clicking it will copy the highlighted portion of table to clipboard. User then can paste it to such applications like MS Word, etc.



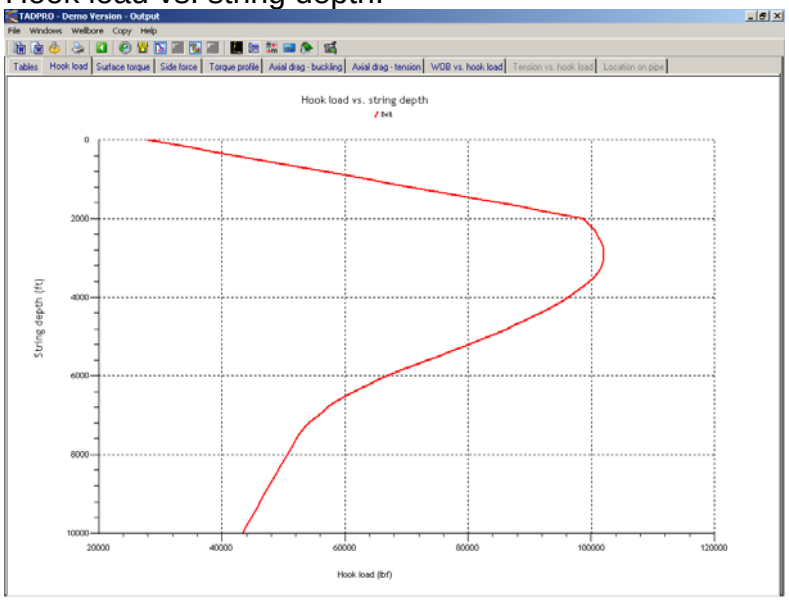
TADPRO can generate MS Word report automatically. From File menu, user can select “Generate MS Word Report” to export all tables and graphs to an editable Word document. The size of generated Word document is about 400K. User can easily modify and e-mail it to clients. graphs to an editable Word document.



IV-2. Engineering charts

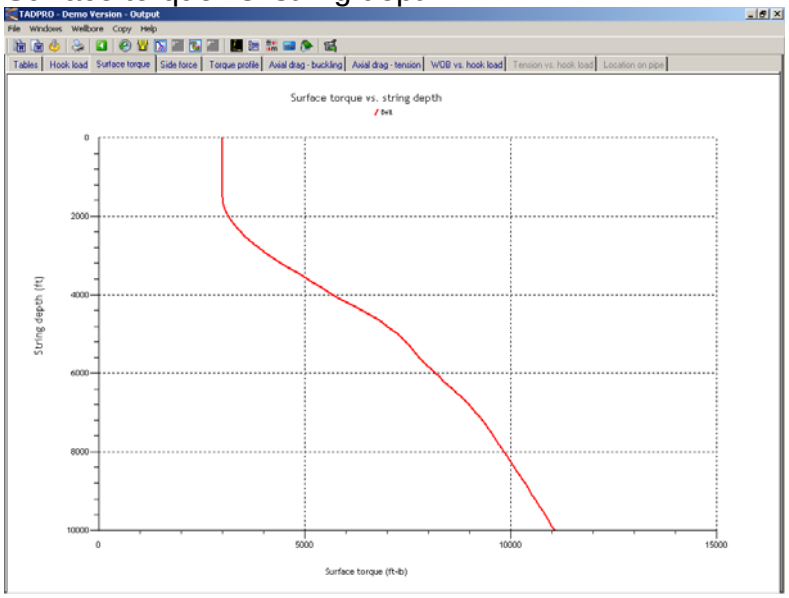
In the Output window, there are 8 engineering graphs, including 2 sensitivity analysis graphs if it is selected.

Hook load vs. string depth.



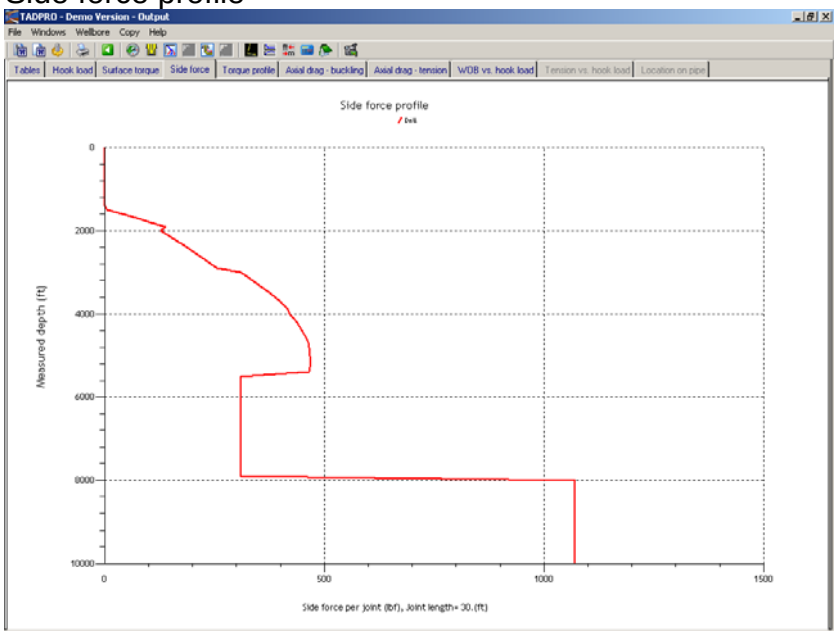
Note that this is a surface hook load history vs. string depth for various operations.

Surface torque vs. string depth.



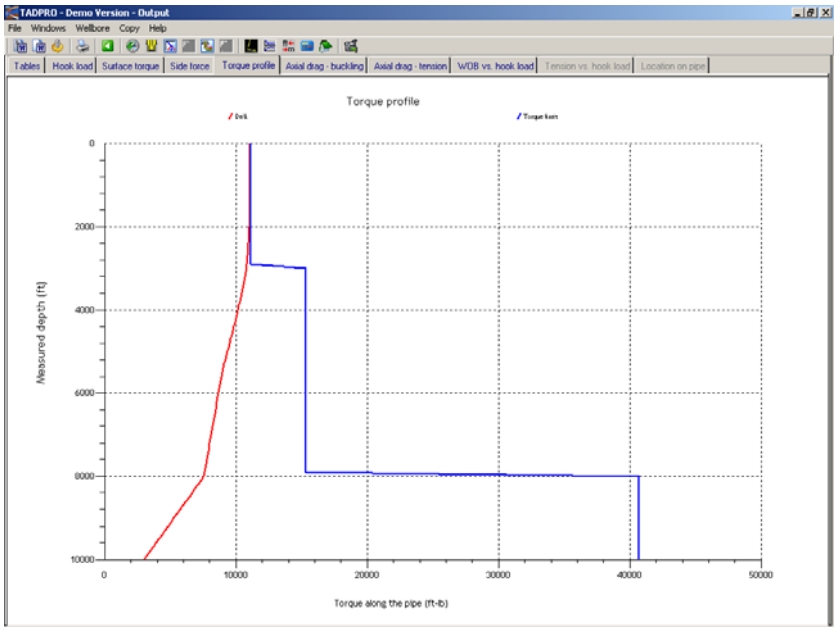
Note that this is a surface torque history vs. string depth for various operations.

Side force profile



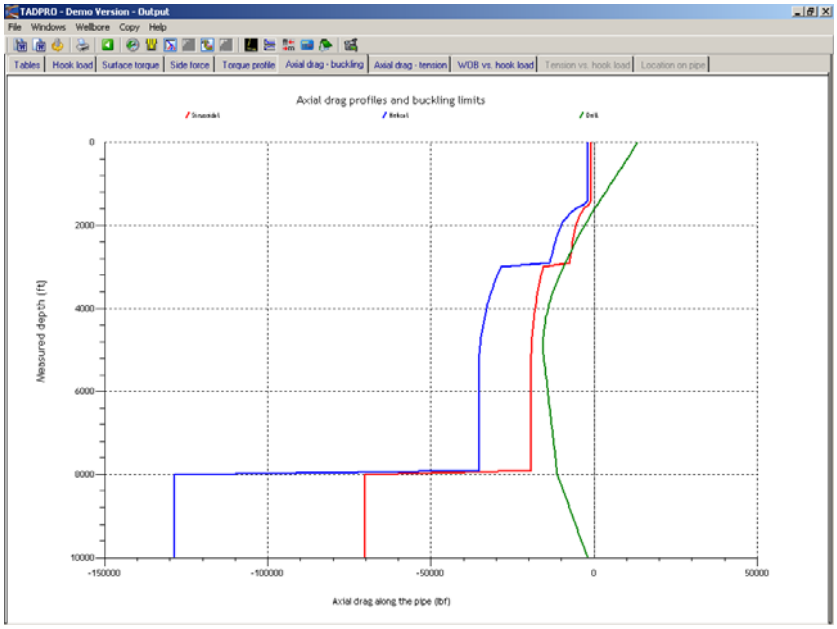
This is “snap shot” of the lateral force distribution along the pipe when the string reaches the TD.

Torque profile



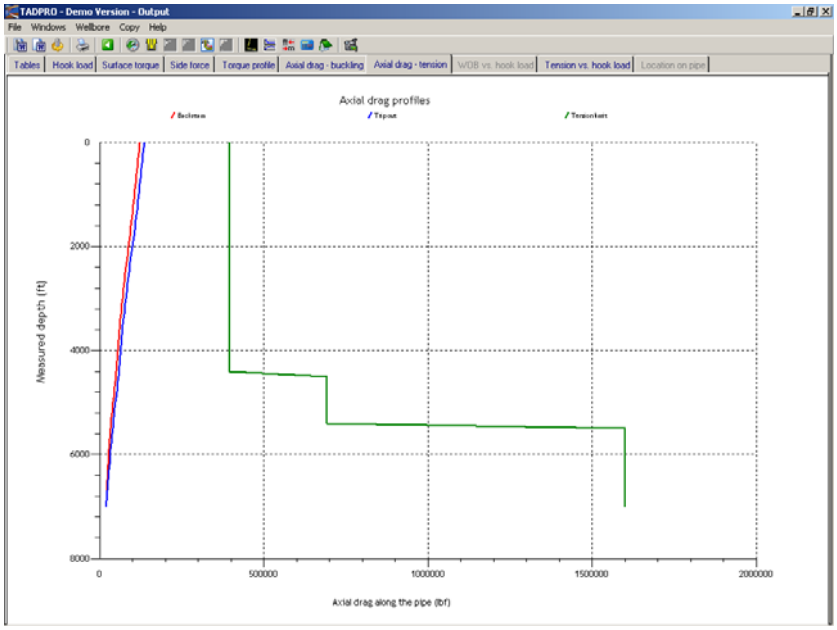
This is “snap shot” of the torque distribution along the pipe when the string reaches the TD.

Axial drag profiles and buckling limits



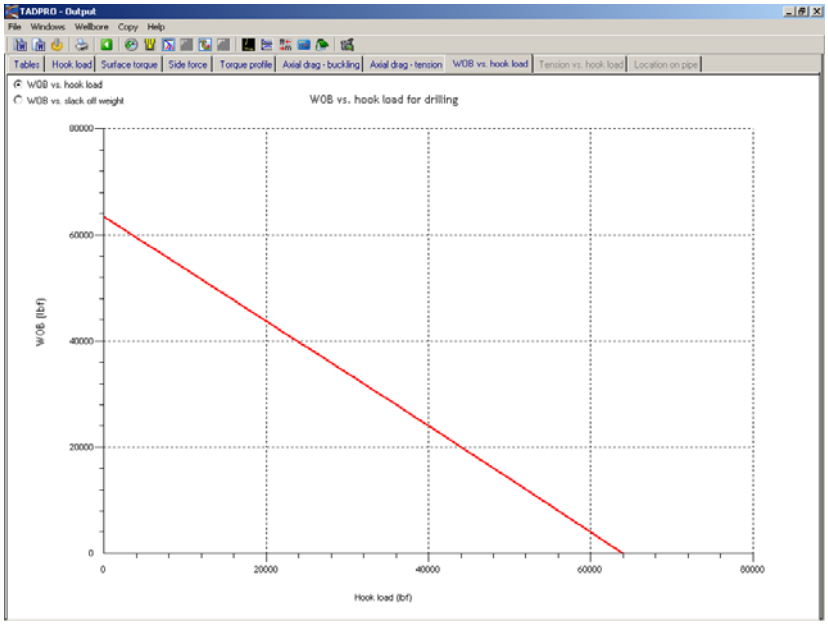
This is “snap shot” of the axial drag distribution along the pipe for slack off / drilling operations when the string reaches the TD. Note that the program also calculates the buckling criteria including 1) sinusoidal buckling, 2) helical buckling.

Axial force profile – pick up



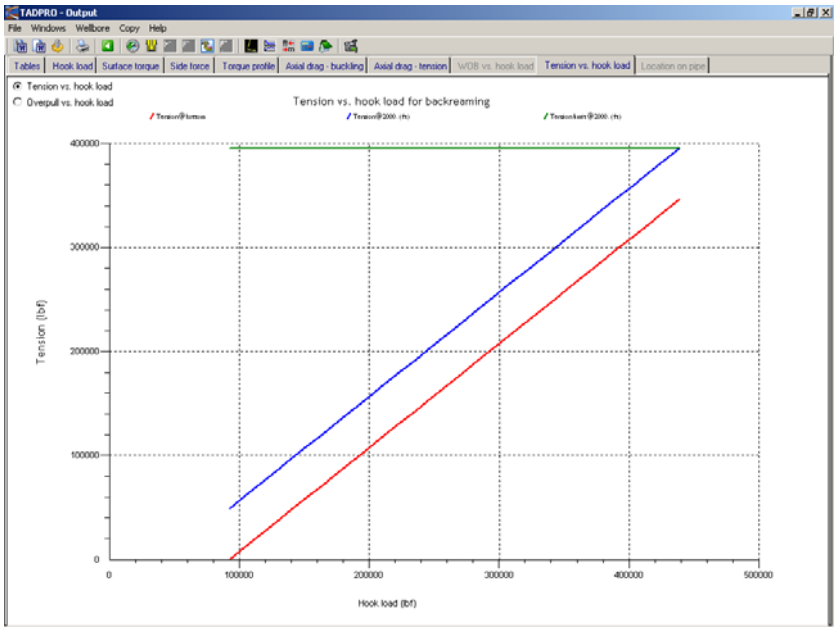
This is “snap shot” of the axial drag distribution along the pipe for pick up operation when the string reaches the TD. Note that the program also displays the tension limit.

WOB vs. hook load for drilling



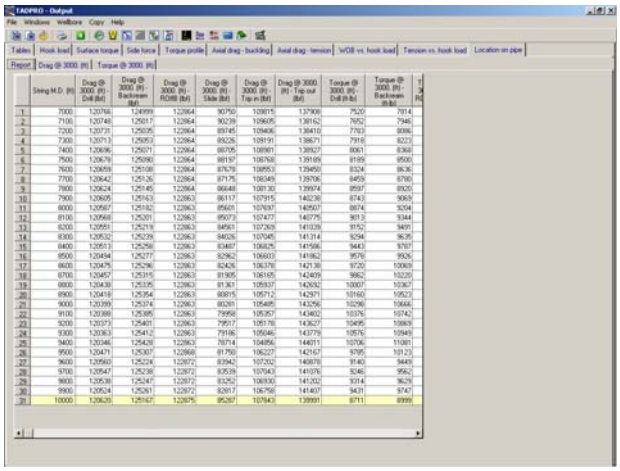
This graph shows the relationship of hook load and WOB for a particular drilling condition - the overall drillibility of the well.

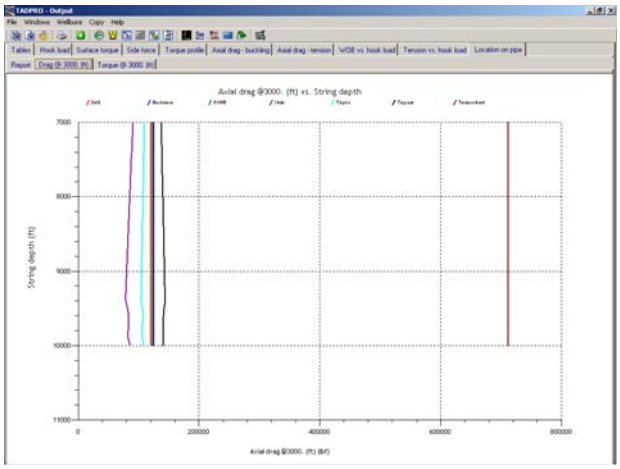
Tension vs. hook load for backreaming

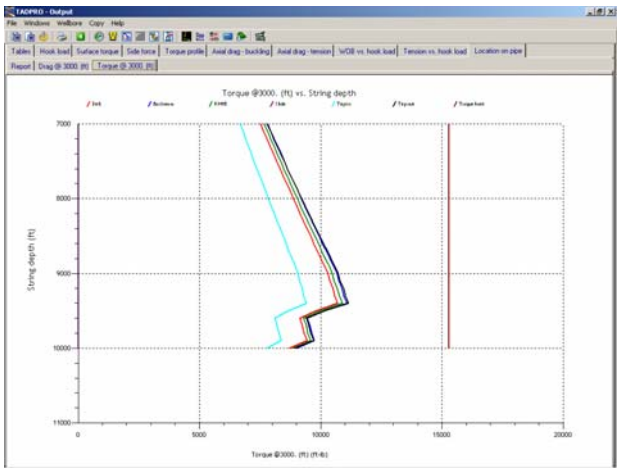


This graph shows the relationship of hook load and tension at bottom and at particular point on the pipe. This assumes that the pipe is stuck at the bottom and you start to pull the pipe at the surface.

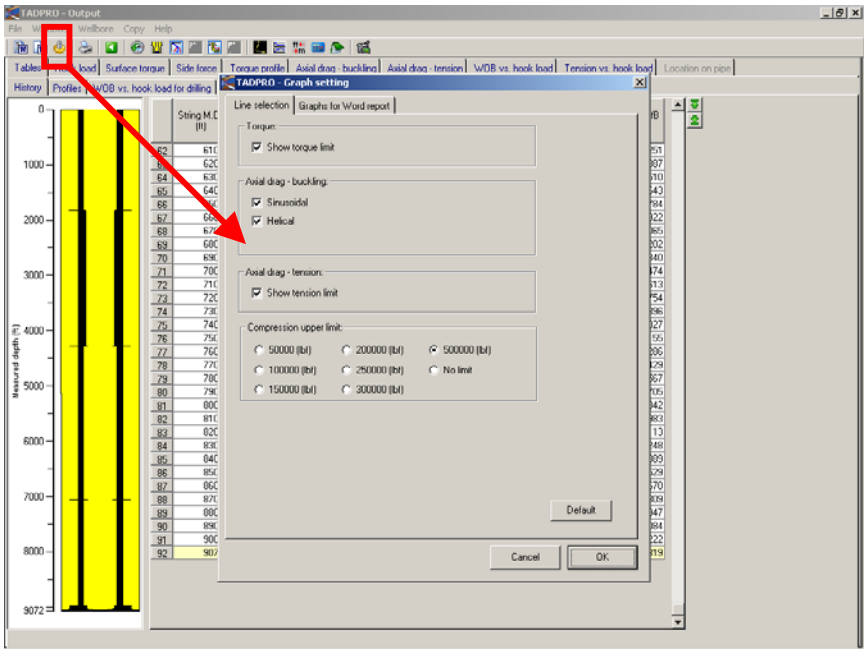
If “Packer setting analysis” in Wellbore page of Input Window is selected, then the program will also display the drag and torque at specified place on the pipe. There are one table and 2 graphs for this analysis.



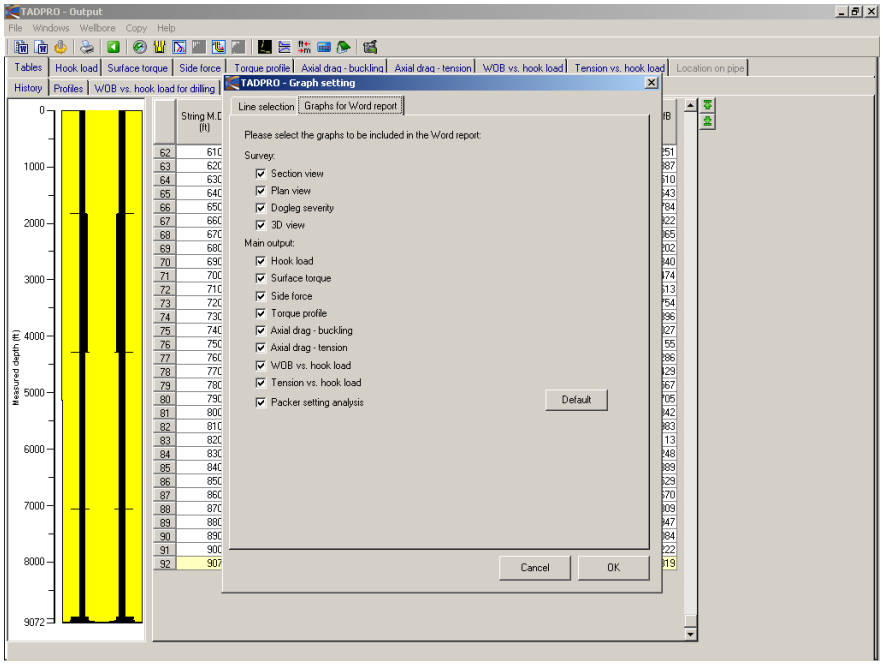




User can customize the graph setting and items to be included in MS Word report by clicking the “Graph setting” button on the toolbar.

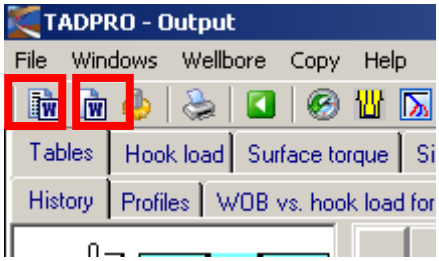


The user can customize all attributes of graph including titles and layouts by right clicking on the graph of interest to open the Graph Control window.

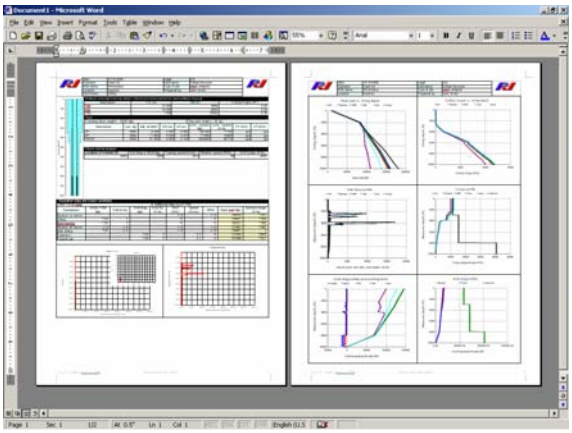


IV-3. MS Word reports

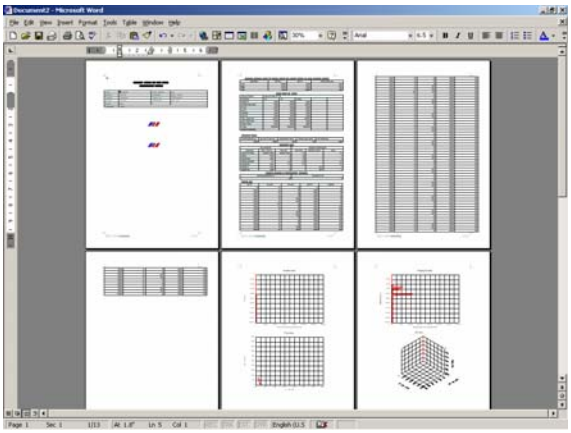
TADPRO can generate 2 types of MS Word report: (1) 2-page summary, or (2) detailed report.



The 1st button on the toolbar is to generate 2 page summary, while the 2nd button is to generate full, detailed report.



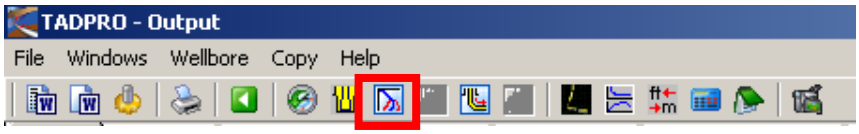
(1) 2-page summary



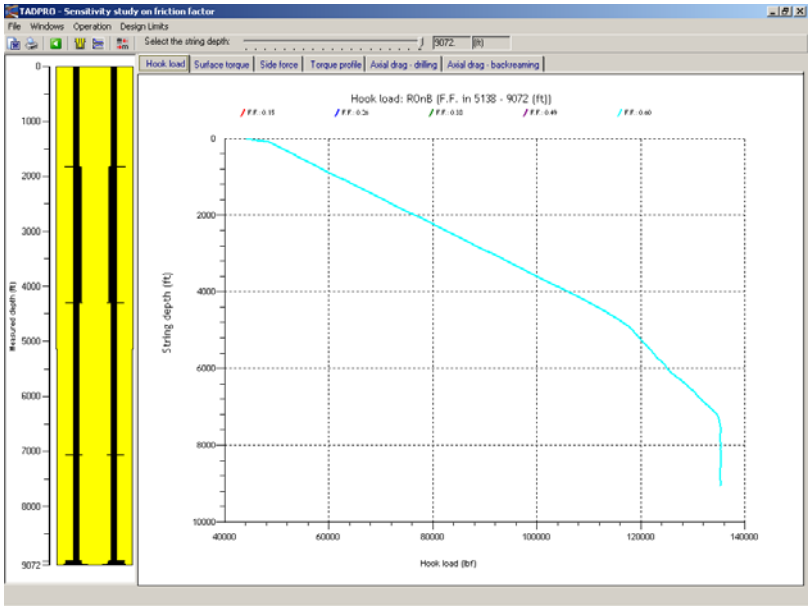
(2) Full report

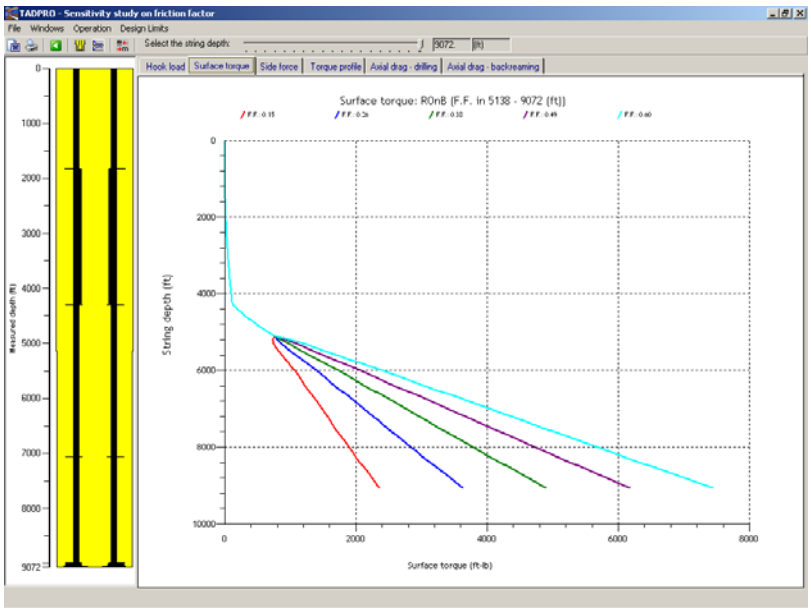
IV-4. Sensitivity analysis

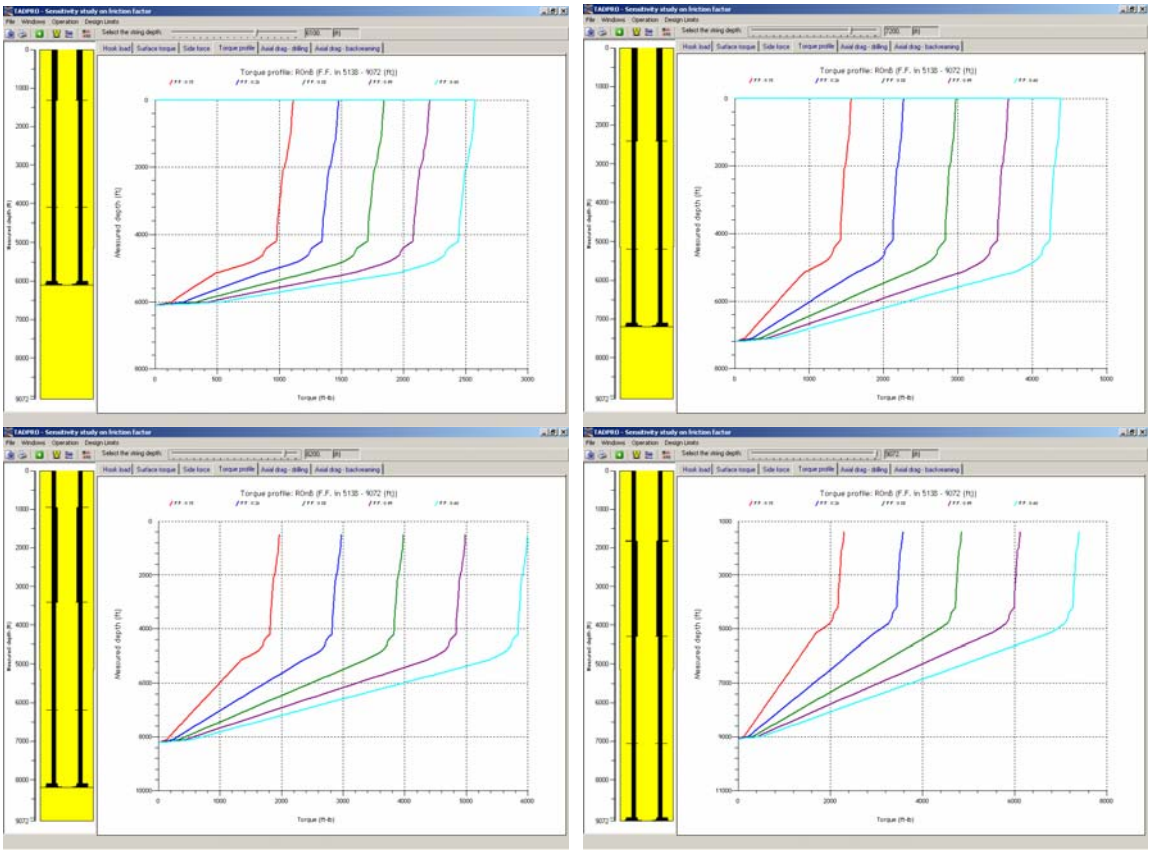
If “Include friction factor sensitivity analysis” in Wellbore page of Input Window is selected, user can view more detailed graphs of sensitivity analysis by clicking the “sensitivity analysis” button on the toolbar. This will open up the Sensitivity Analysis Window.



This window allows the user to view the load profiles along the pipe when the string depth is varying from surface to TD. Note that these profiles are dynamically changing when the string is moving along the wellbore.

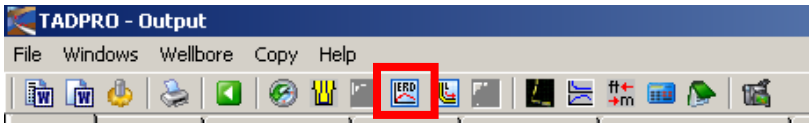




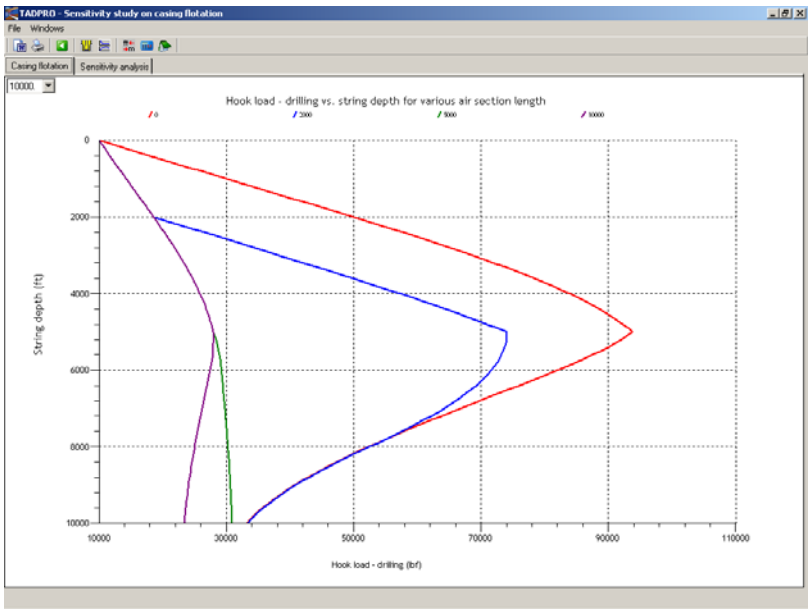


IV-5. Casing flotation

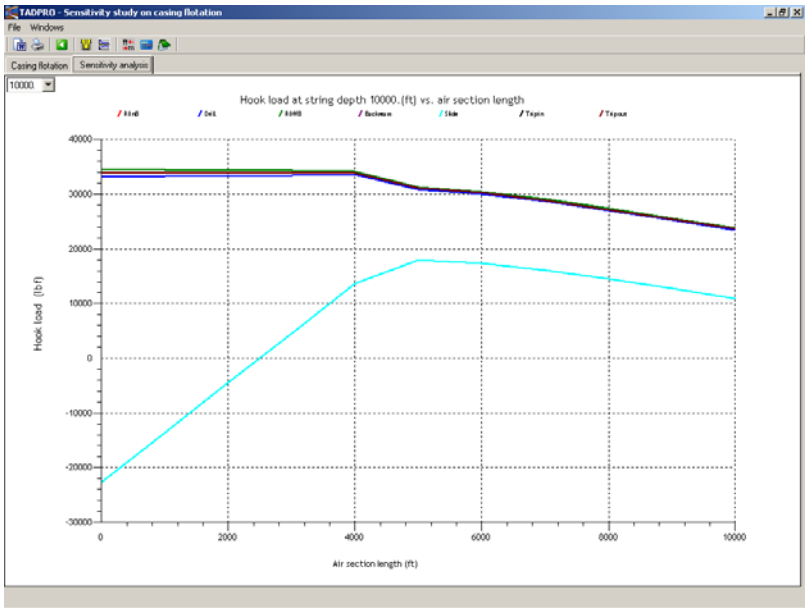
If “Consider casing flotation” check box in the Operation page of Input Window box is selected, user can view impacts of air section length on hook load by clicking the “casing flotation” button on the toolbar. This will open up the Casing Flotation Window.



Hook load (slack off) vs. string depth for various air section length:

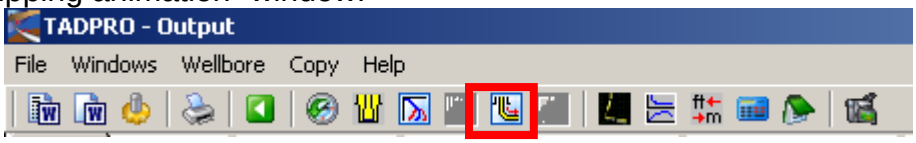


Hook load at certain depth vs. air section length (sensitivity analysis):

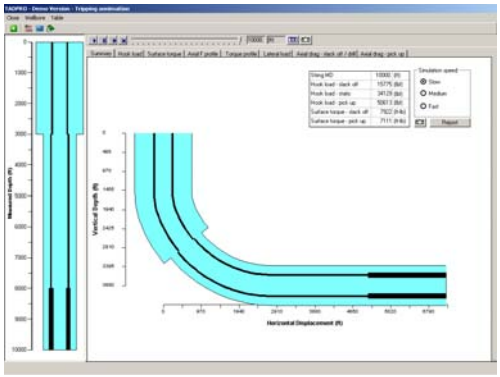


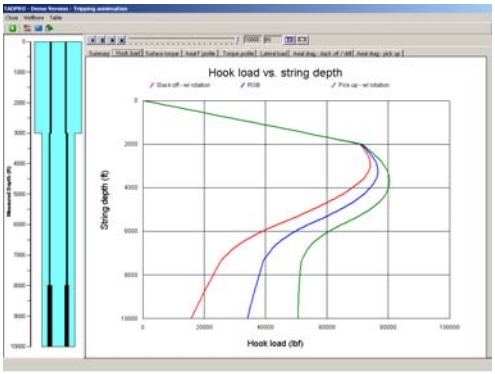
IV-6. Tripping animation

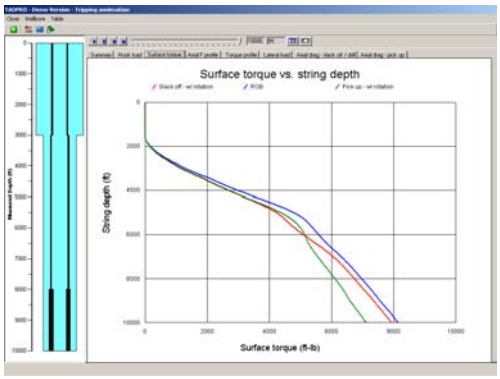
On the toolbar, there is a button called “Animation”. Clicking it will open “Tripping animation” window.

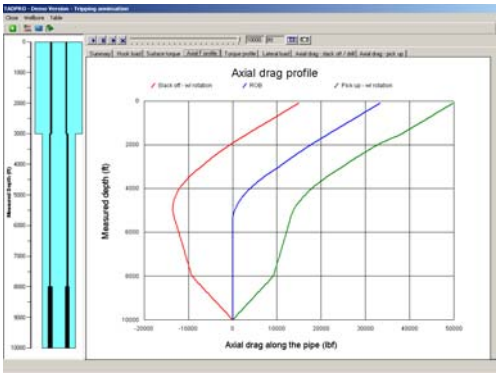


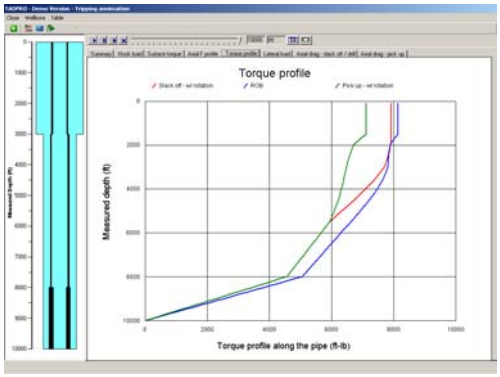
Clicking through the tabs to view all the corresponding graphs.

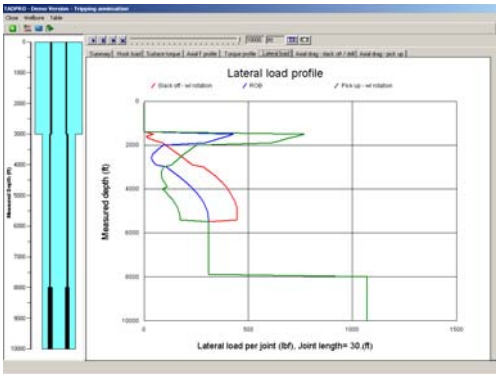


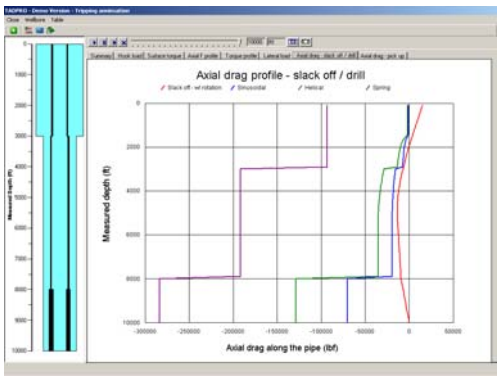


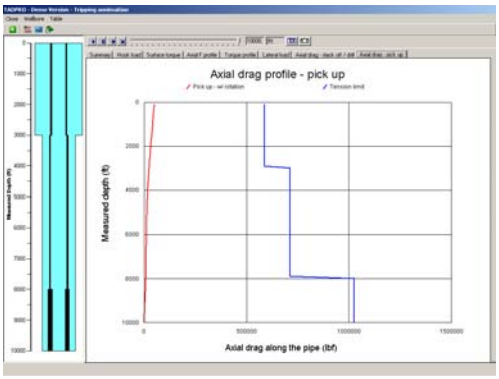




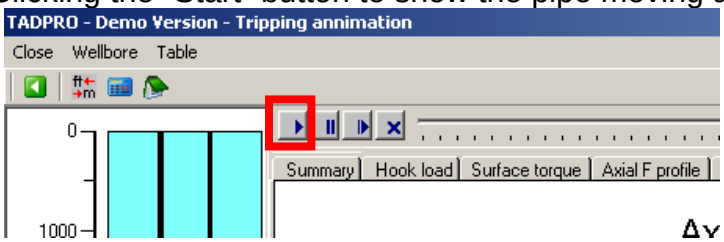


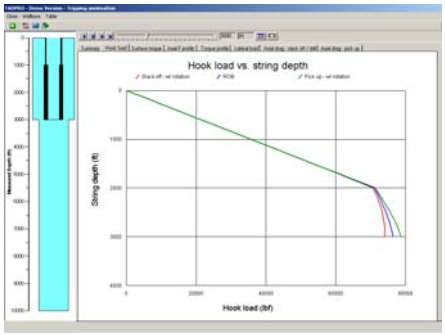


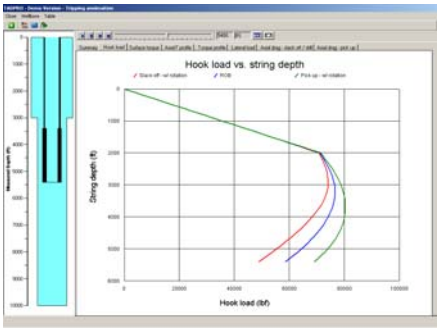


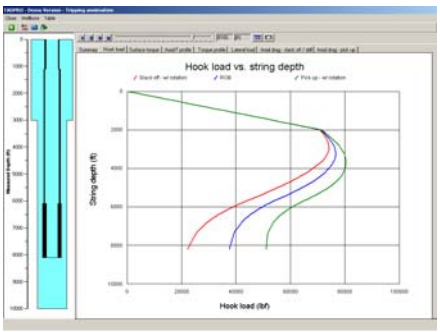


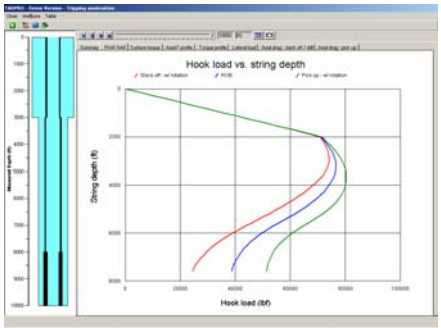
Clicking the “Start” button to show the pipe moving animation.



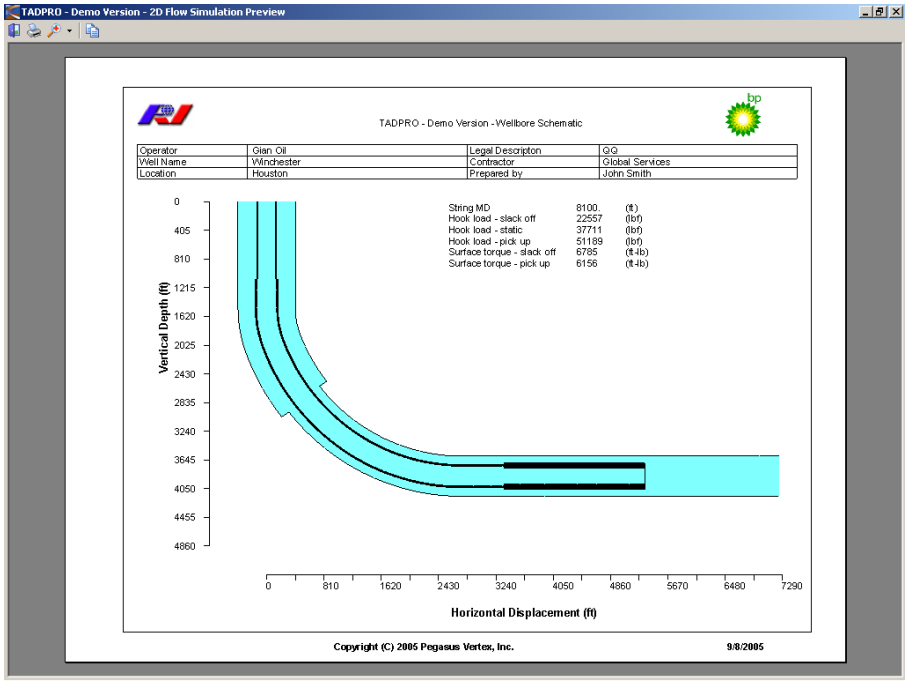




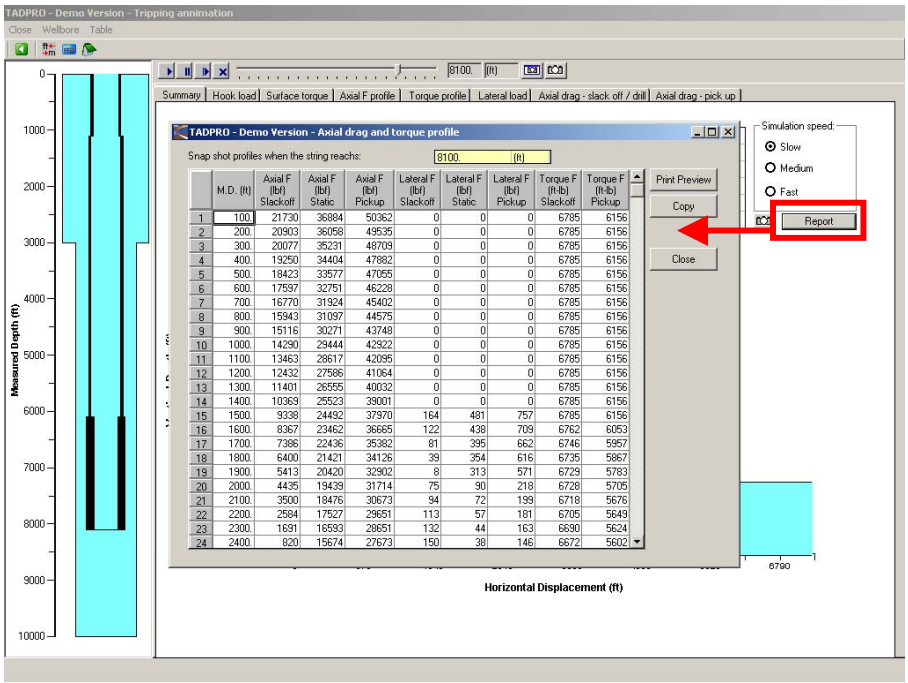




In the 1st tab, user can click the “Deviated wellbore preview” button within the plotting area, a wellbore schematic with the summary data at that string depth will be displayed as shown below.



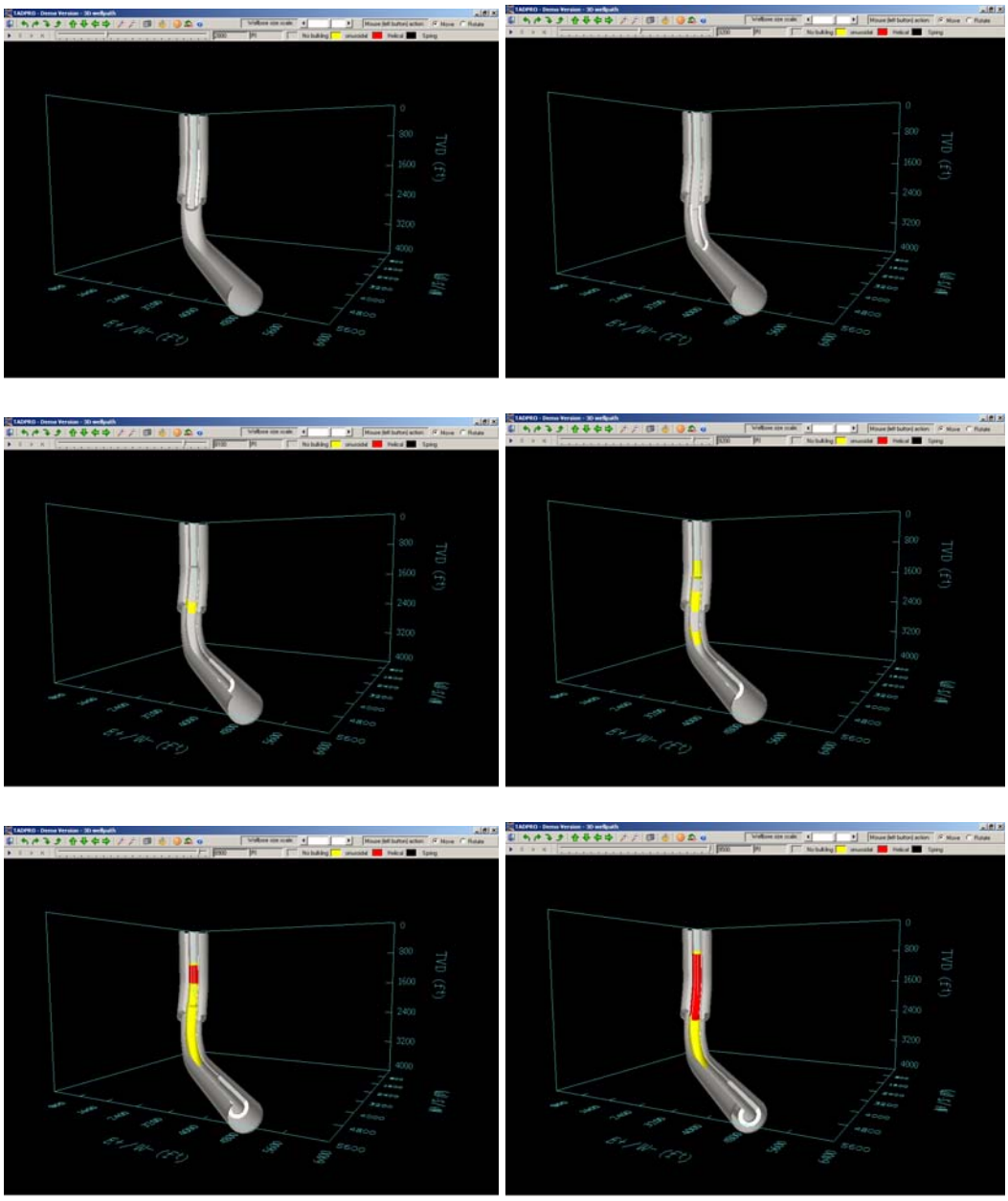
User can also view the load profile for each string depth by clicking the “Report” button within the plotting area.



IV-7. 3D animation - drilling

TADPRO is equipped with a more advanced visualization tool called 3D tripping animation. User can click the button on the toolbar to open this window.

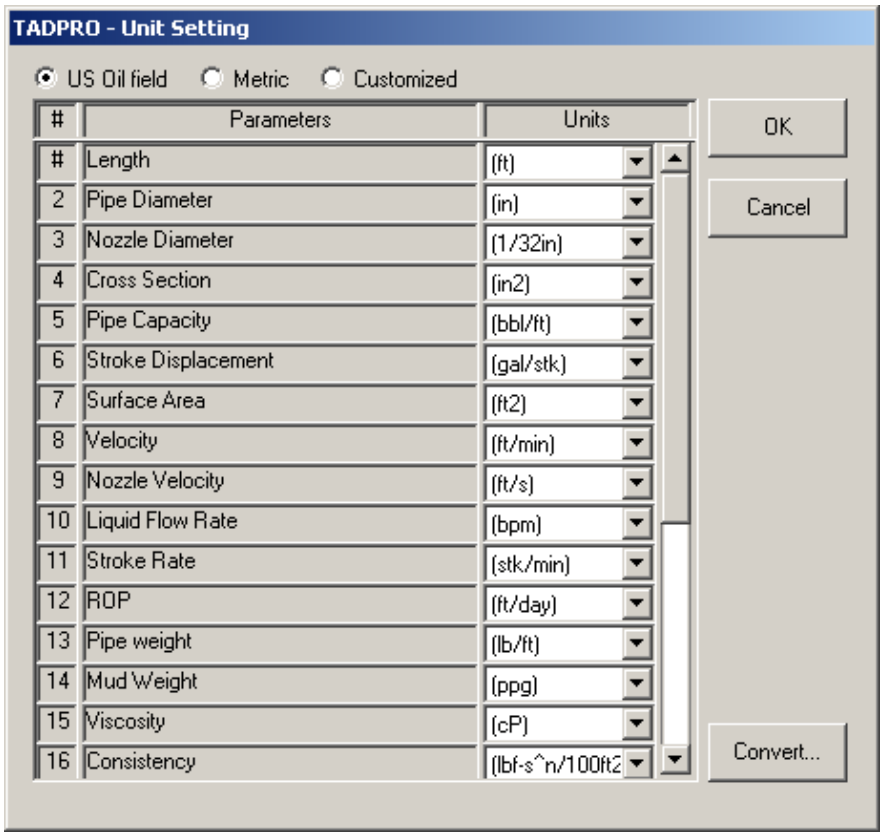
The 3D tripping animation not only shows the pipe/wellbore configuration at different string depth, but also shows the buckling status of pipe.



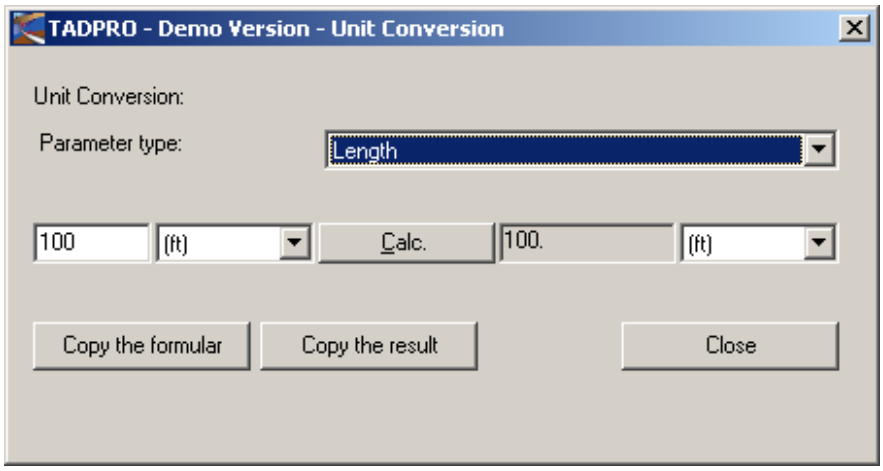
V. Other Windows

V-1. Units

Select "Customized" to make changes to any of the units. Pulling down the drop-down box attached to each quantity accesses allowable options for each quantity.



The "Convert" button will convert between different units.



VI. References

1. C.A. Johancsik, et al, “Torque and Drag in Directional Wells – Prediction and Measurement”, SPE Reprint Series, No. 30, Directional Drilling, 1990 Edition, Page 130

2. Dawson, Rapier and Paslay, P.R., “Drillpipe Buckling in Inclined Holes,” SPE Reprint Series, No. 30, Directional Drilling, 1990 Edition, Page 148

3. Jiang Wu and H.C. Juvkam-Wold, “Drilling and Completing Horizontal Wells with Coiled Tubing”, SPE 26336, October 1993.

4. Jiang Wu and H.C. Juvkam-Wold, “Coiled Tubing Buckling Implication in Drilling and Completing Horizontal Wells”, SPE DC, March 1995, Vol. 10, No. 1, Page 16-21.

5. Bourgoyne, A.T., Jr., et al., 1986: Applied Drilling Engineering, Society of Petroleum Engineers, Richardson, Texas.

VII. About Pegasus Vertex, Inc.

Pegasus Vertex, Inc. (PVI) is an engineering consulting and software company specializing in computer modeling of drilling and completion operations for petroleum industry. Our software products are born from the marriage of cutting-edge petroleum innovations and state-of-the-art computer technologies. Together with our software products, a big portion of our business is software customization for our clients.

Equipped with software development strength and sound petroleum engineering skills, we are confident to provide our customers with not only what we have, but also what they want.

For more information on PVI's software, services and capabilities, visit us on the Internet at

http://www.pvicom.com

or contact us in Houston, Texas by:

Pegasus Vertex, Inc.
6100 Corporate Dr., Suite 448
Houston, TX 77036
Tel: 713-981-5558; Fax: 713-981-5556
E-mail: sales@pvicom.com